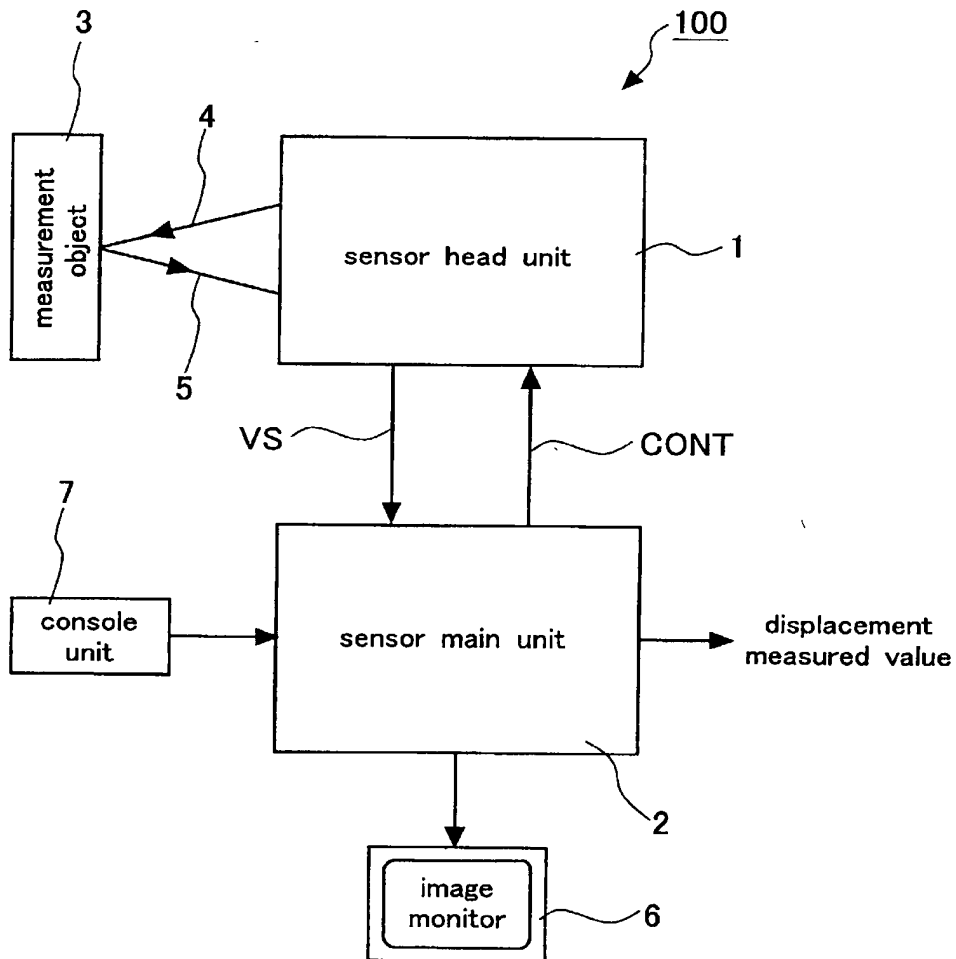


Fig. 1



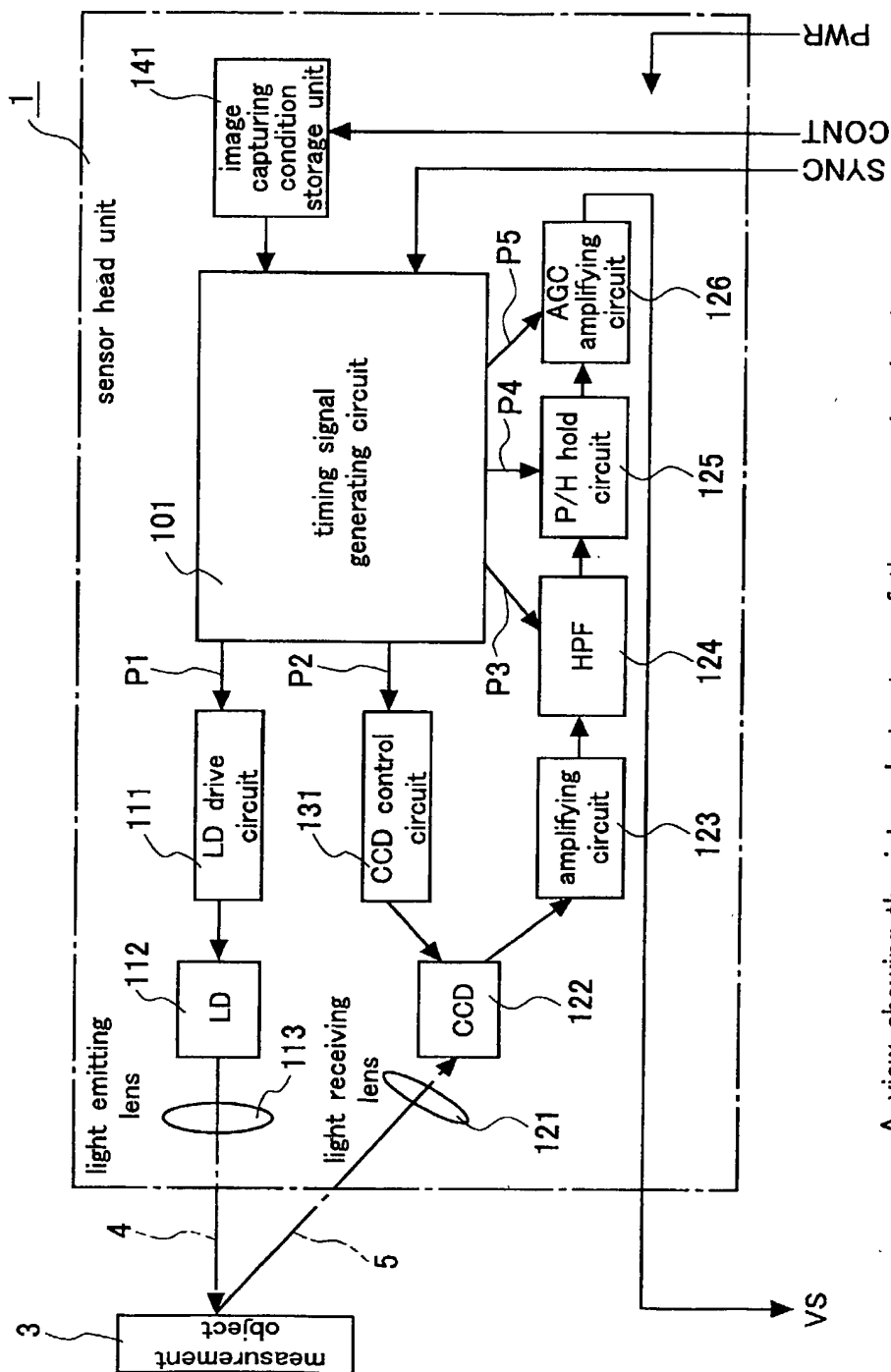
An overall view of a visual displacement sensor

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SENSOR
Inventor(s): Tatsuya Matsunaga, et al.
DOCKET NO.: 058856-0106

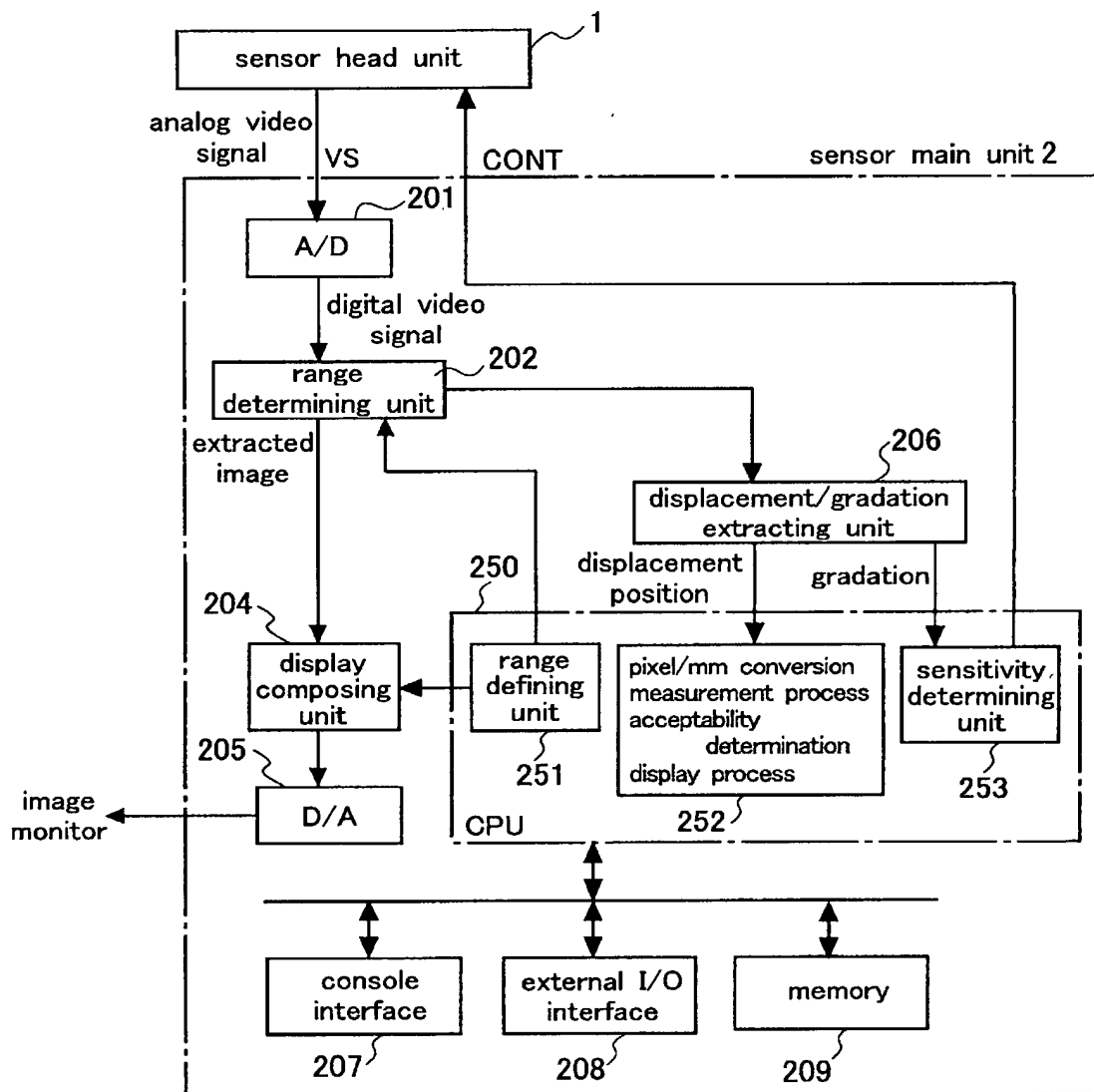
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Fig. 2



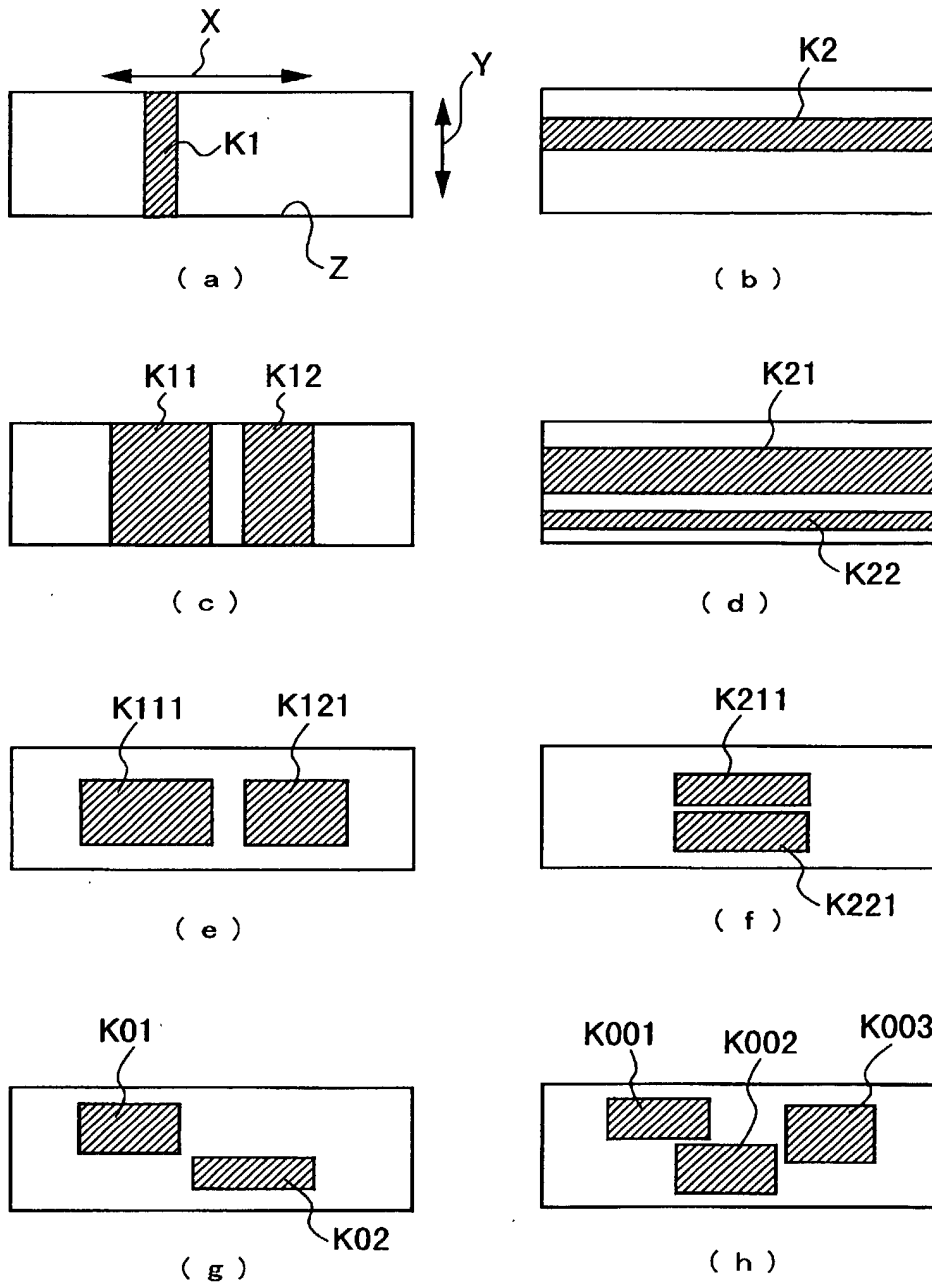
A view showing the internal structure of the sensor head unit

Fig. 3



A block diagram (part 1)
showing the functional internal structure of the sensor main unit

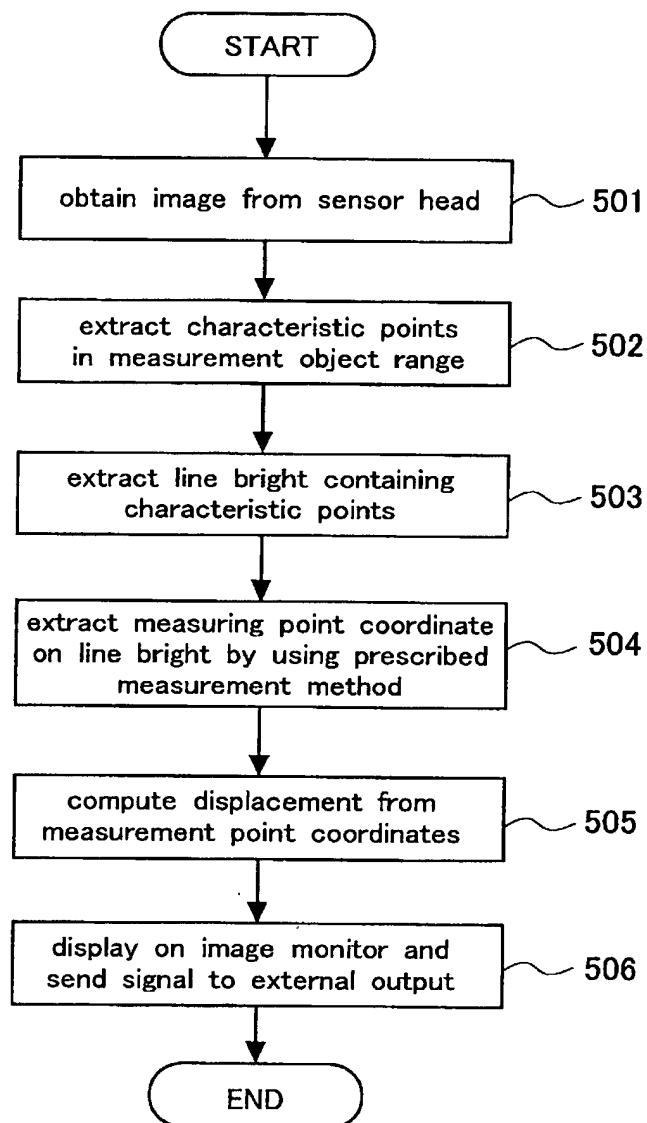
Fig. 4



A view showing a mode of defining measurement object ranges

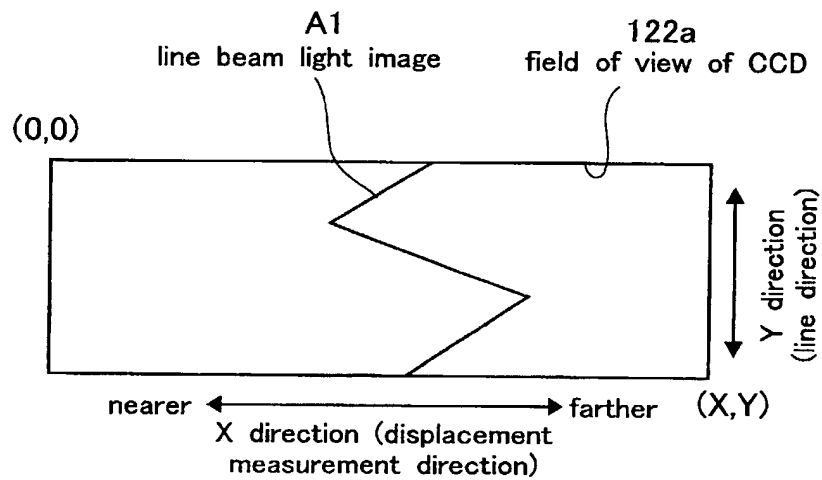
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Fig. 5



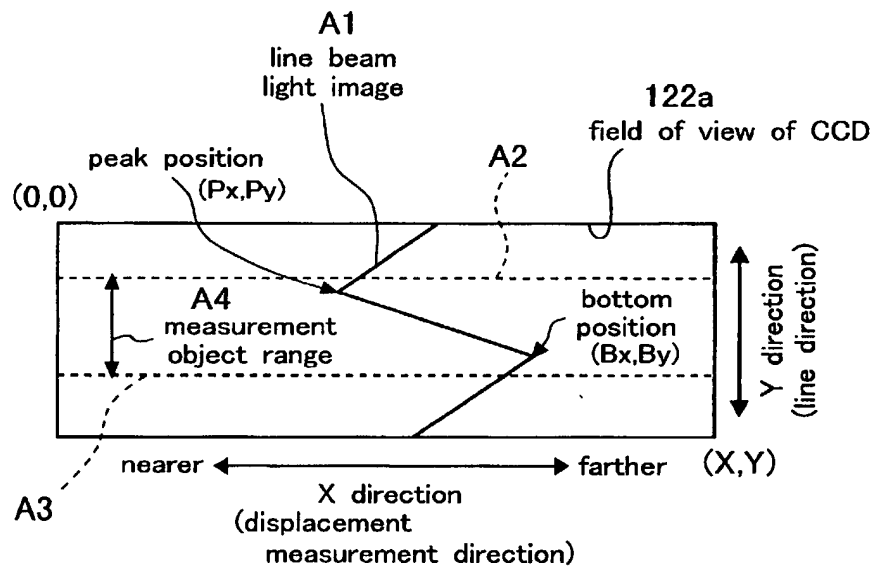
A general flow chart schematically illustrating the operation of the displacement measurement by the sensor main unit

Fig. 6



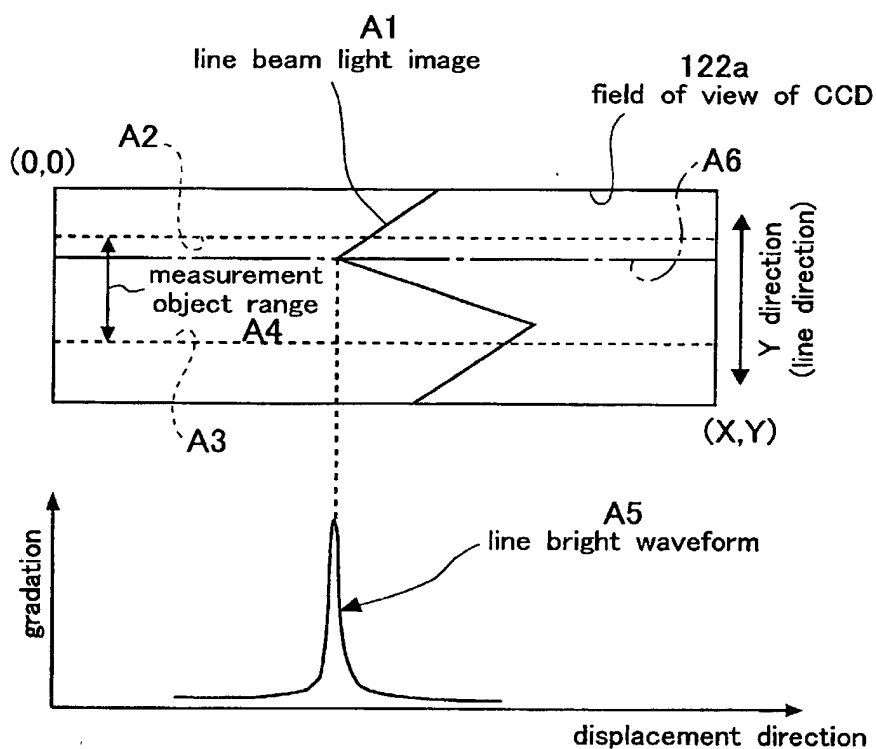
A view illustrating an image
captured by the CCD incorporated in the sensor head unit

Fig. 7



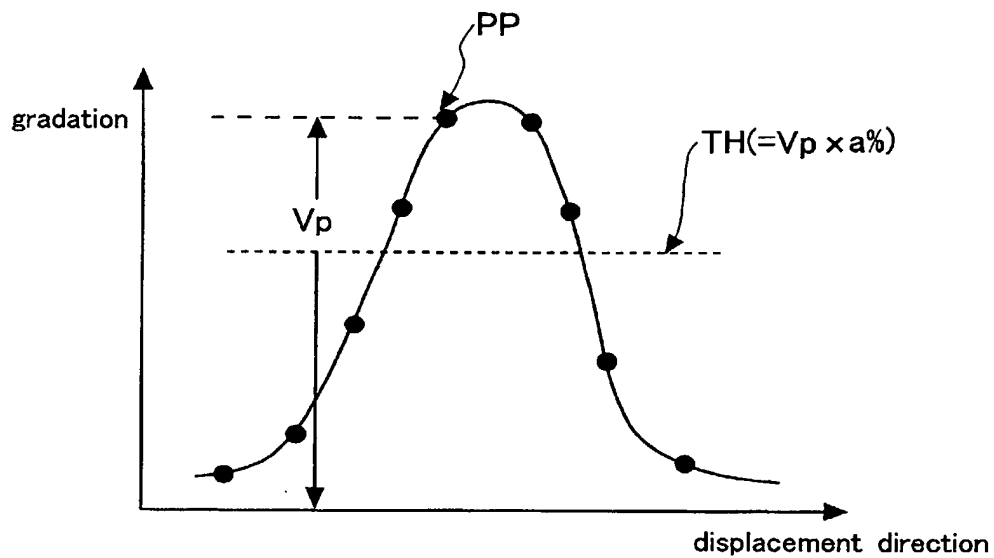
A view illustrating the process of
extracting measurement points in a measurement object range

Fig. 8



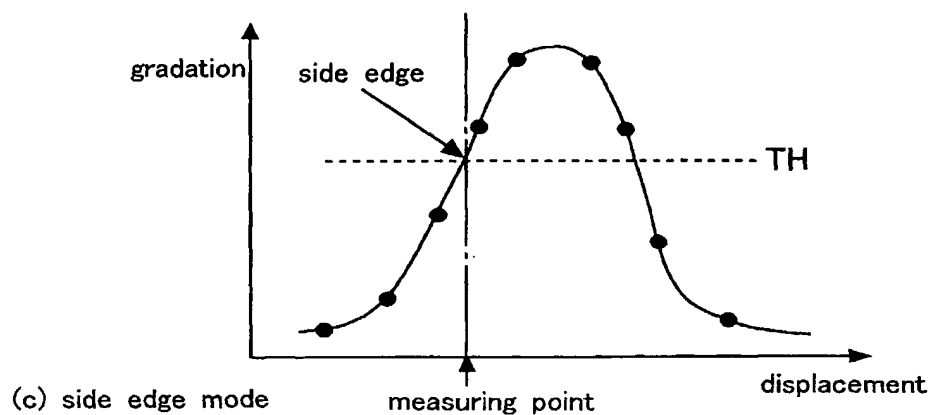
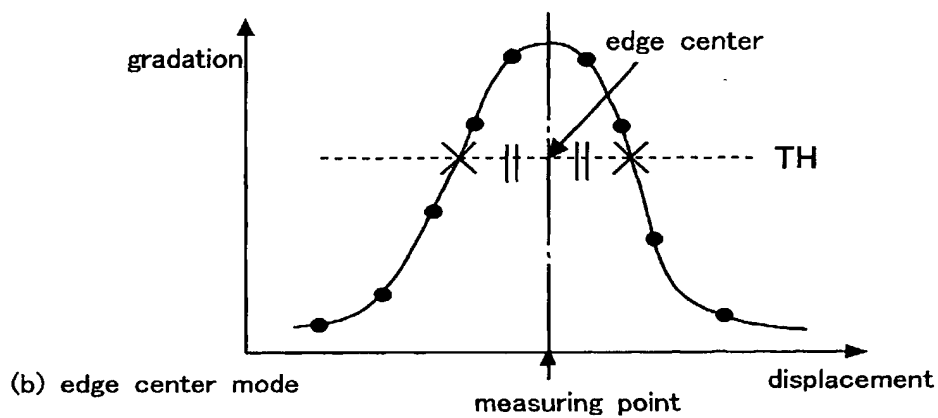
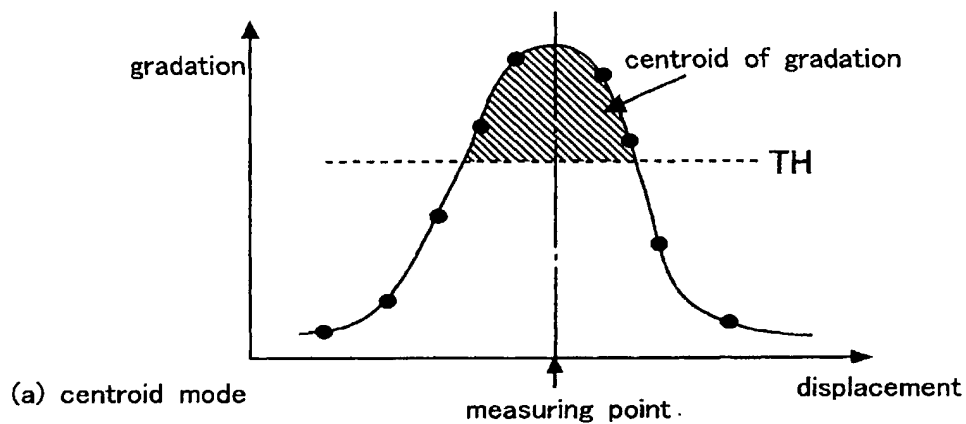
A view illustrating the relationship
between the line bright waveform and the image captured by the CCD

Fig. 9



An illustrative view showing the process of determining the threshold value

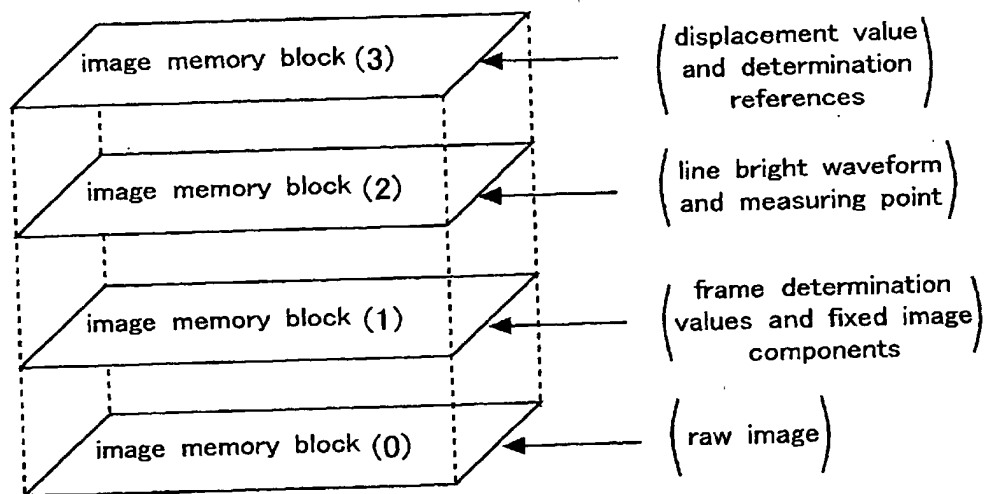
Fig. 10



An illustrative view showing the process
of extracting the measuring point coordinate

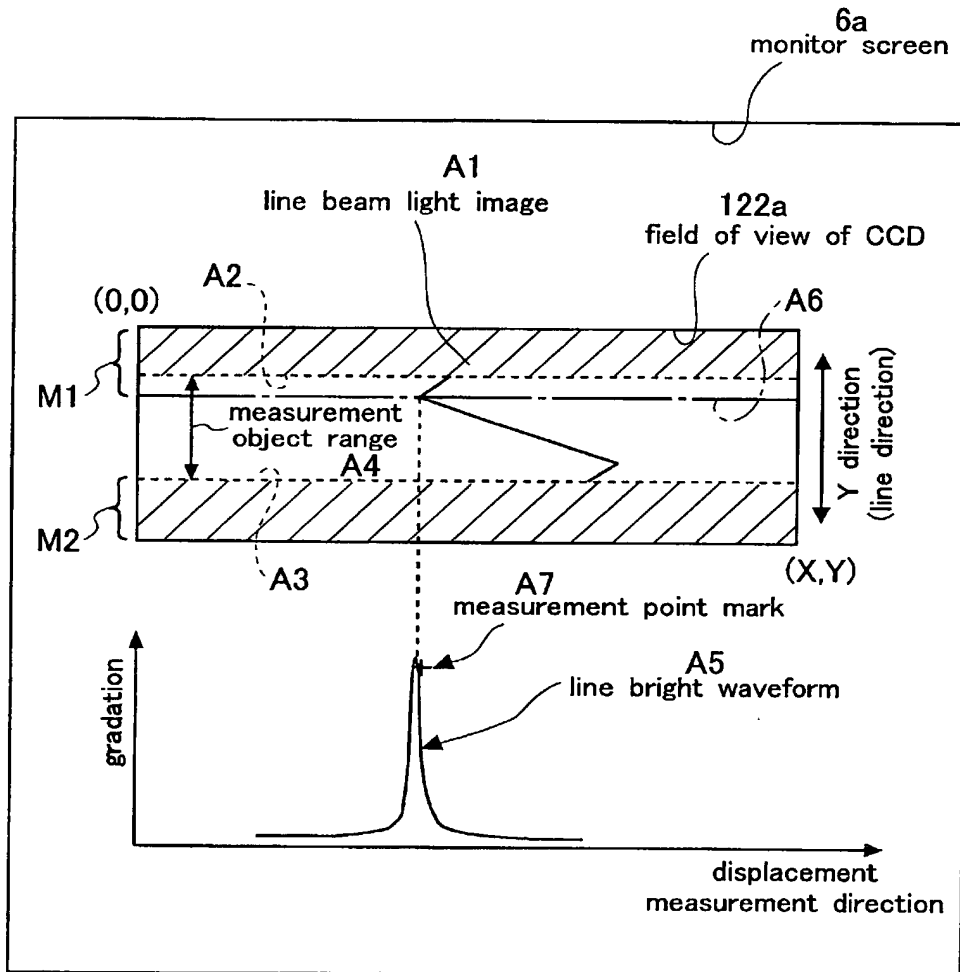
0937480 092604

Fig. 11



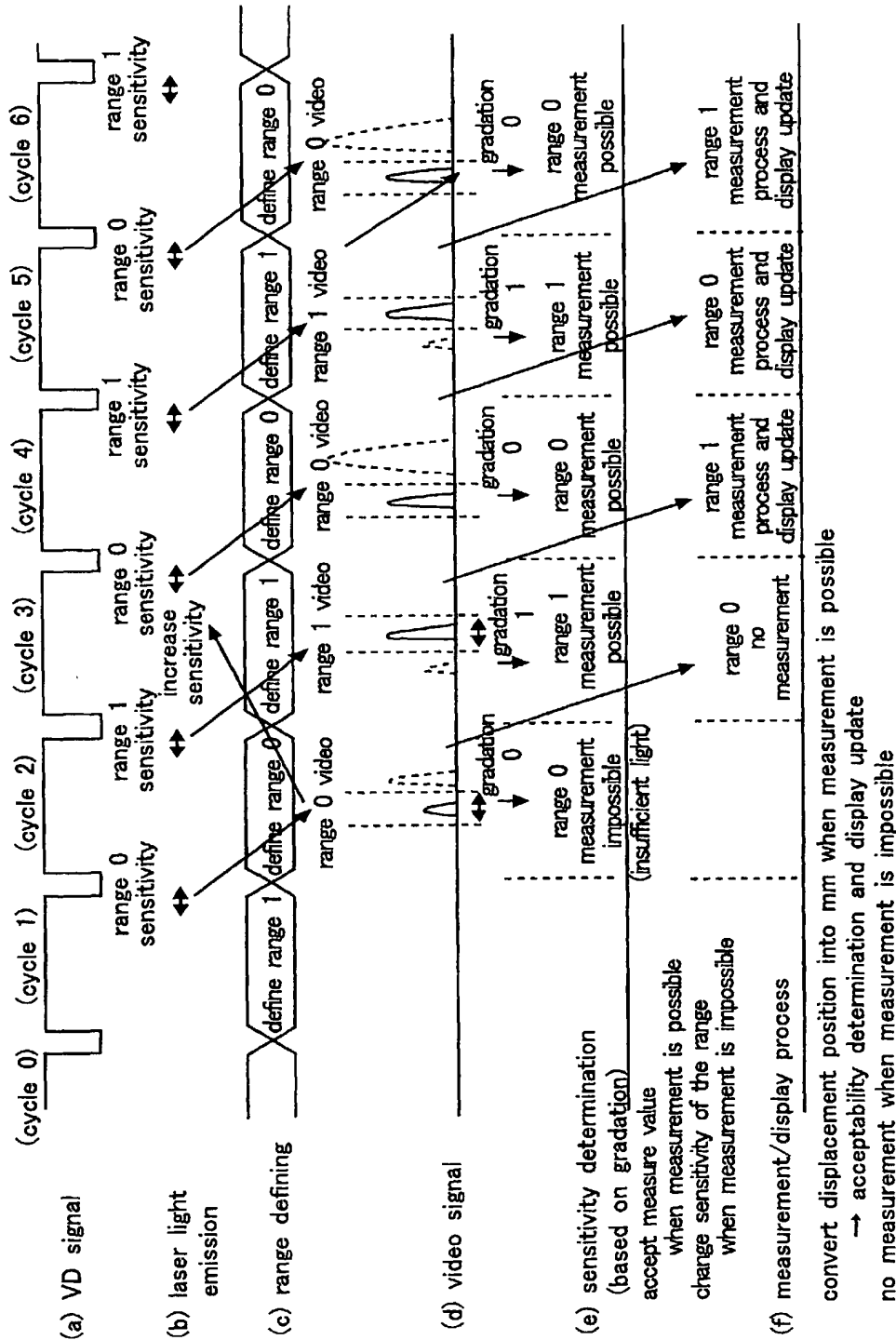
An illustrative view showing the process of generating the monitor display

Fig.12



A view showing an exemplary monitor display showing the relationship between the image captured by the CCD and line bright waveform

Fig.13



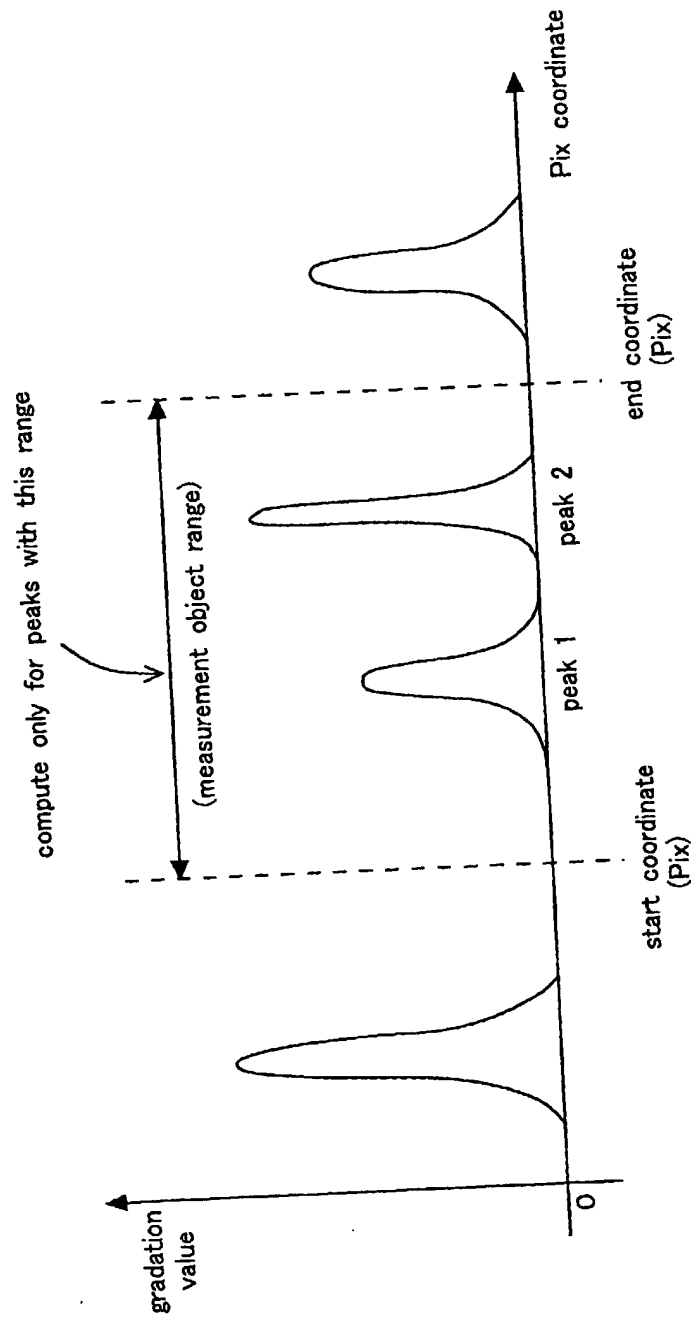
A time chart showing the gradation adjustment process for each range

09260" 0811/0660

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Inventor(s): Tatsuya Matsunaga, et al.
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Fig.14



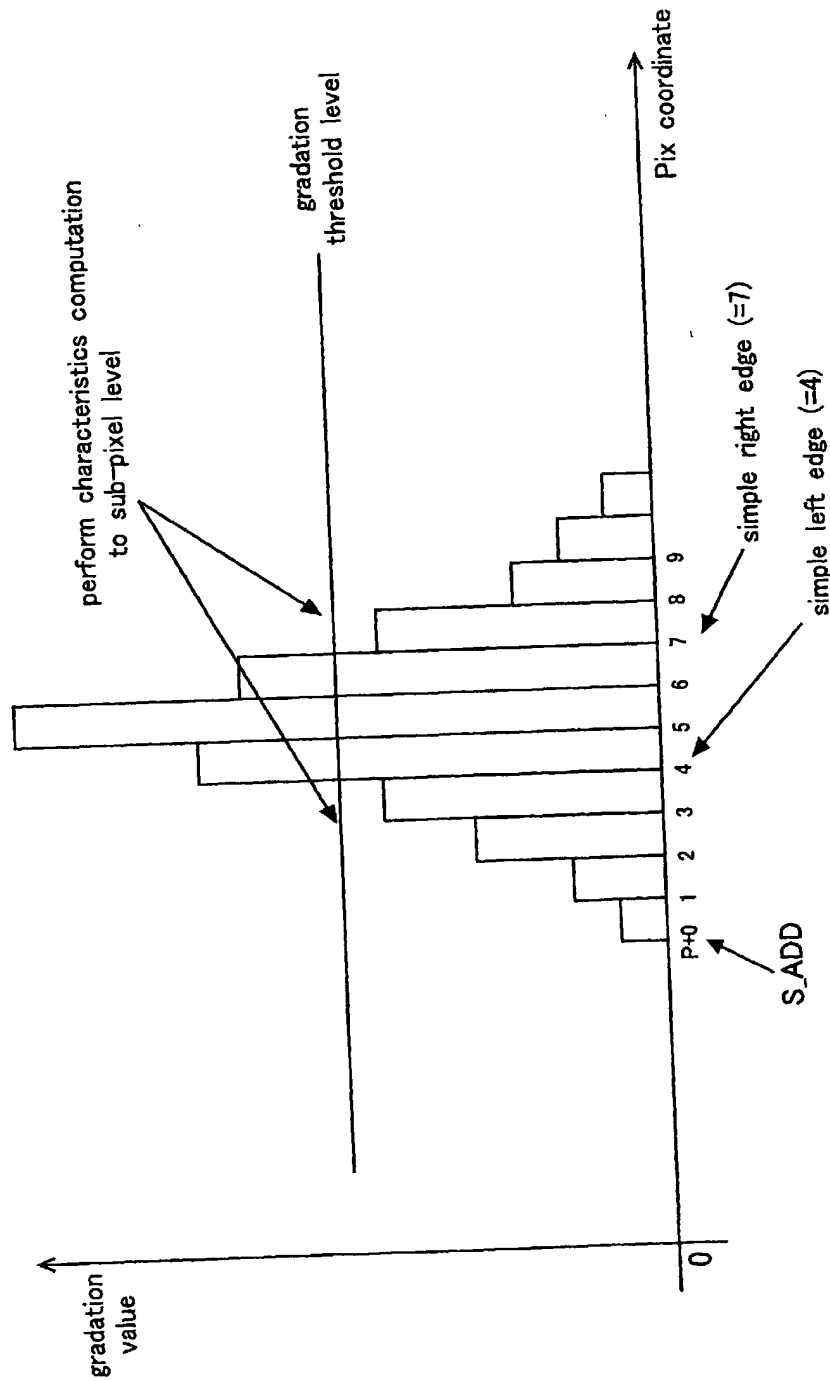
A view illustrating the relationship between the line bright waveform and measurement object range

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Fig.15

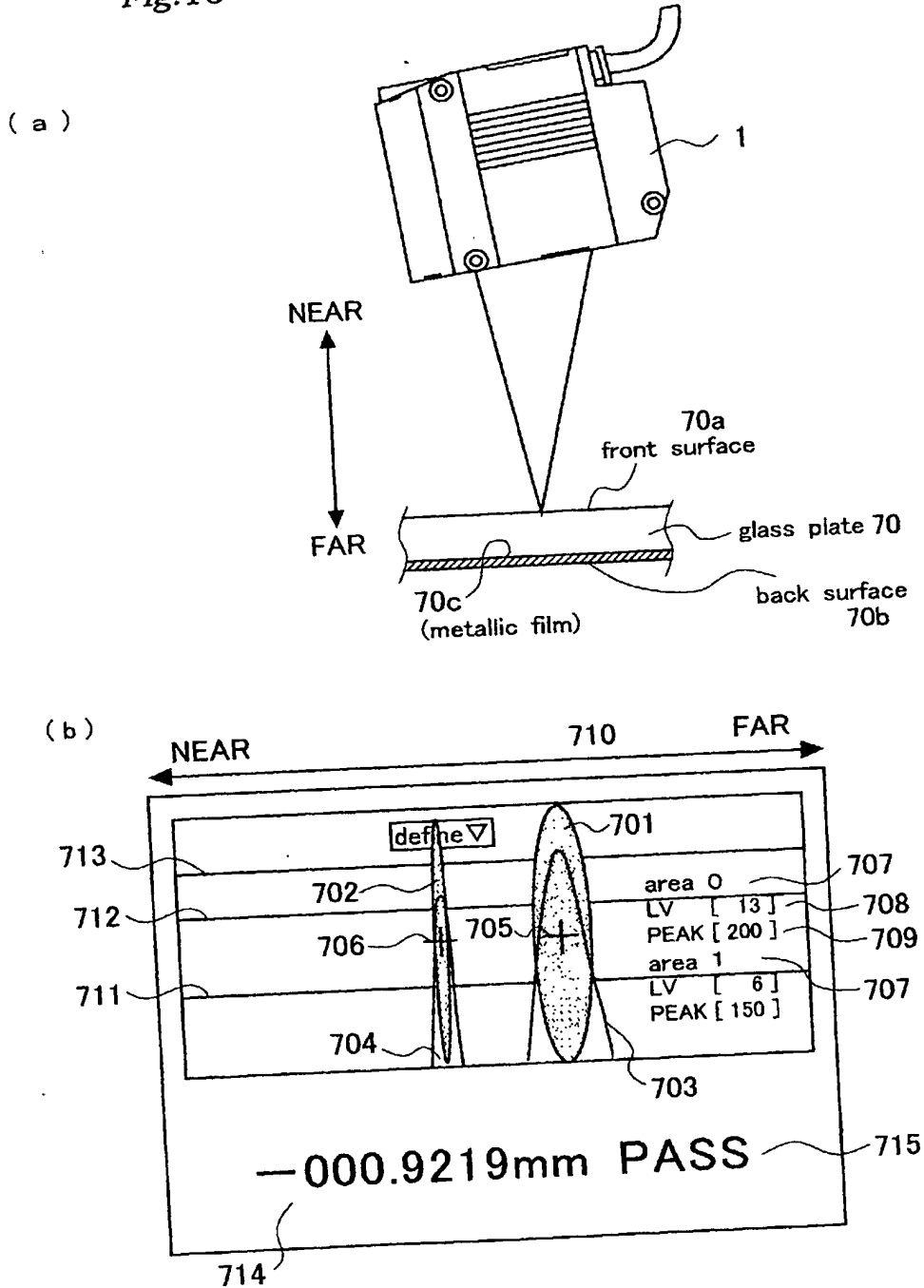


A view illustrating the characteristic computation for determining measurement point coordinates

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Inventor(s): Tatsuya Matsunaga, et al.
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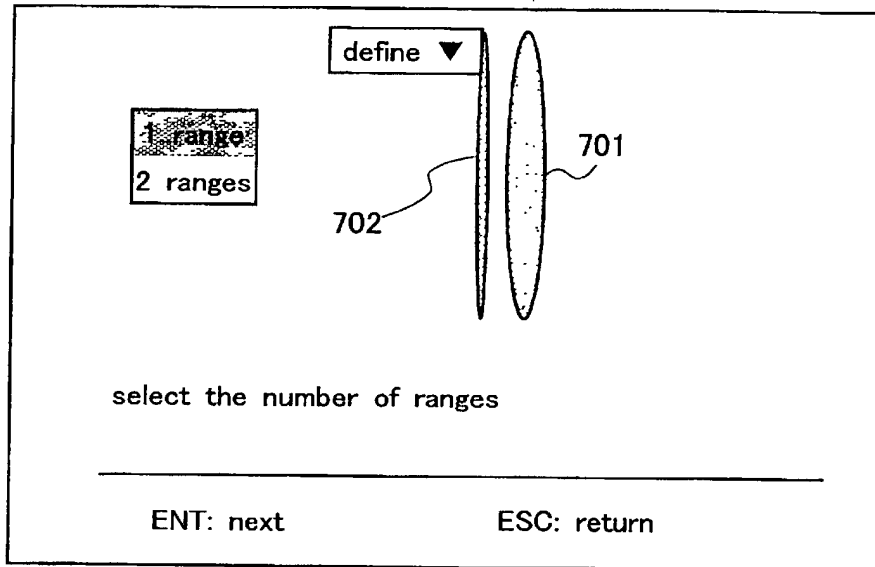
Fig.16



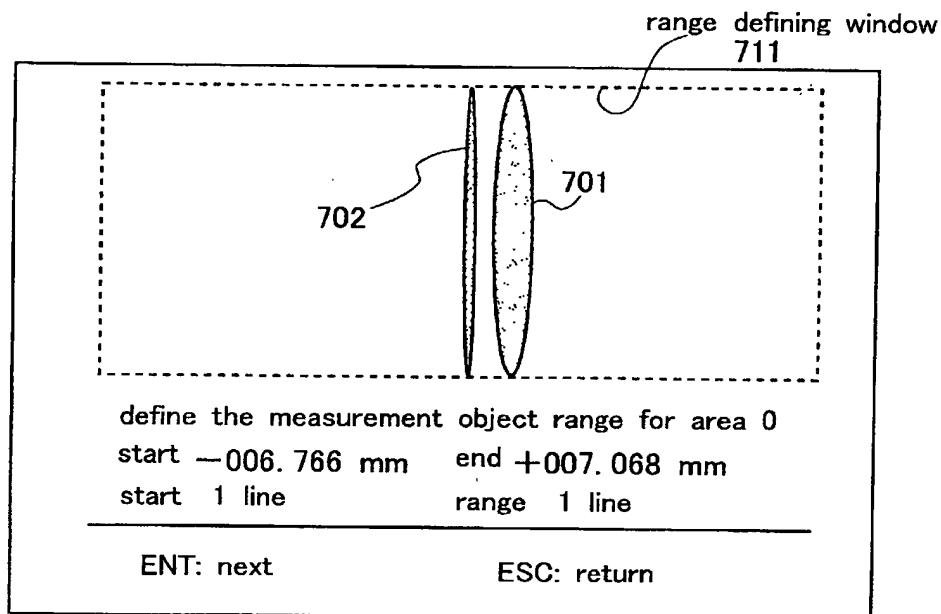
a view showing a conventional measurement result

0937480-092601

Fig. 17



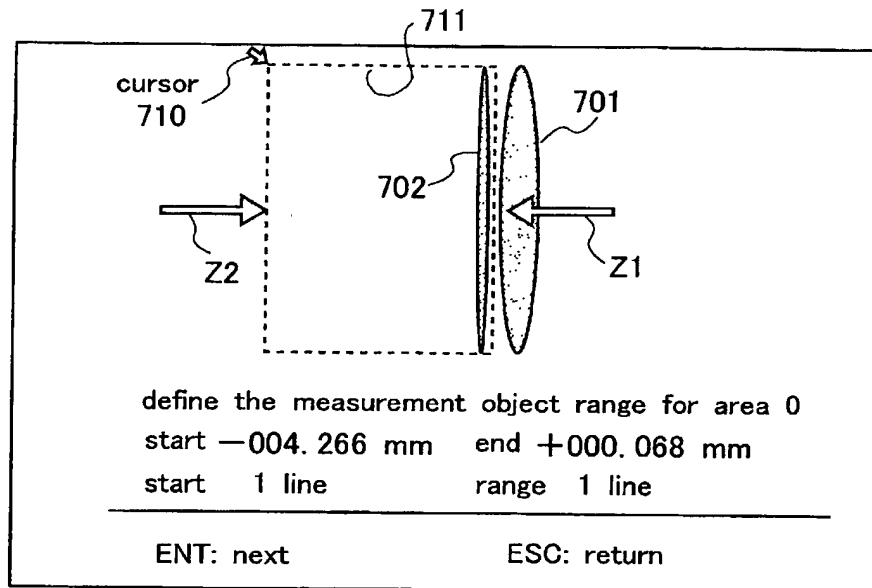
(a) selecting the number of ranges to be defined



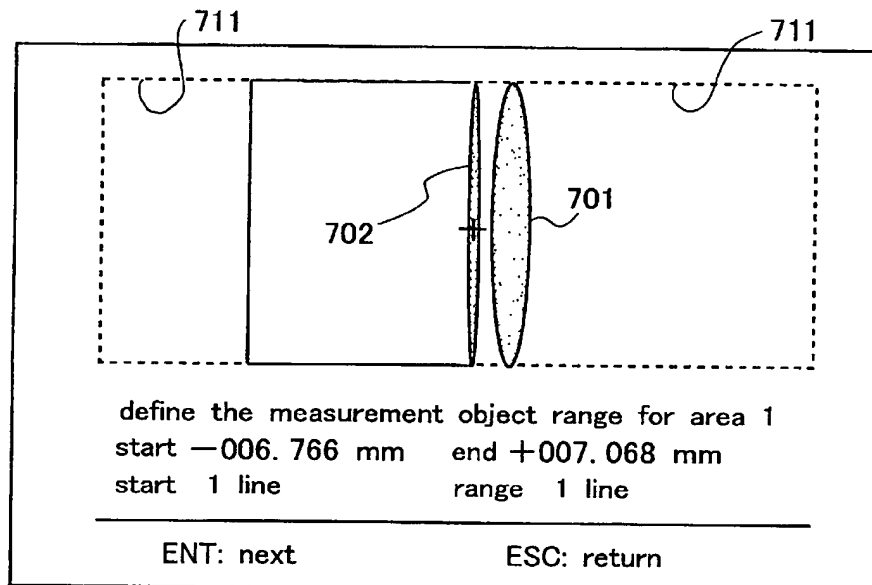
(b) defining measurement object range 0

A view illustrating the monitor screen when defining regions (part 1)

Fig. 18



(a) defining measurement object range 0



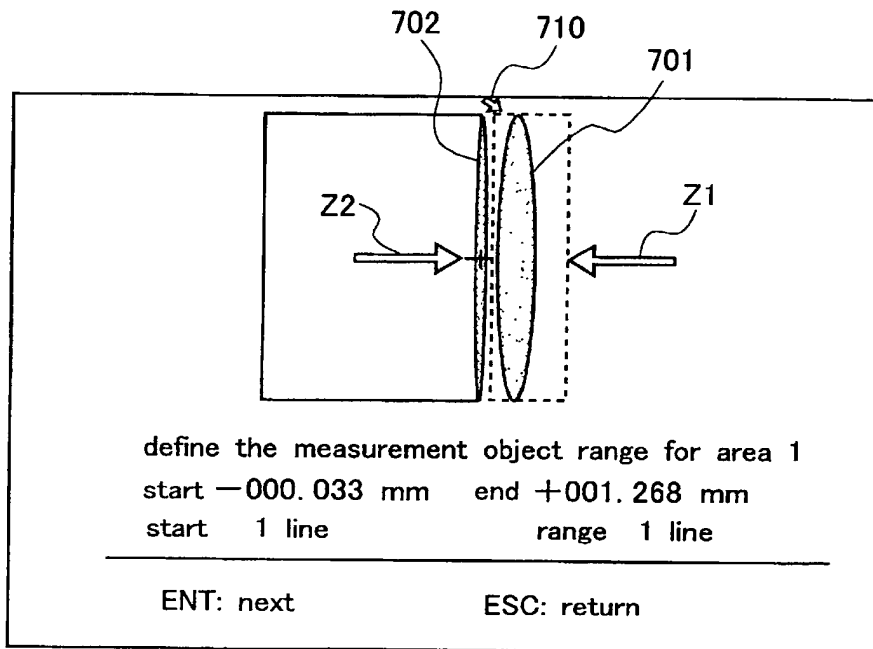
(b) complete the defining of measurement object range 0
(acquire a relative reference position)

A view illustrating the monitor screen when defining regions (part 2)

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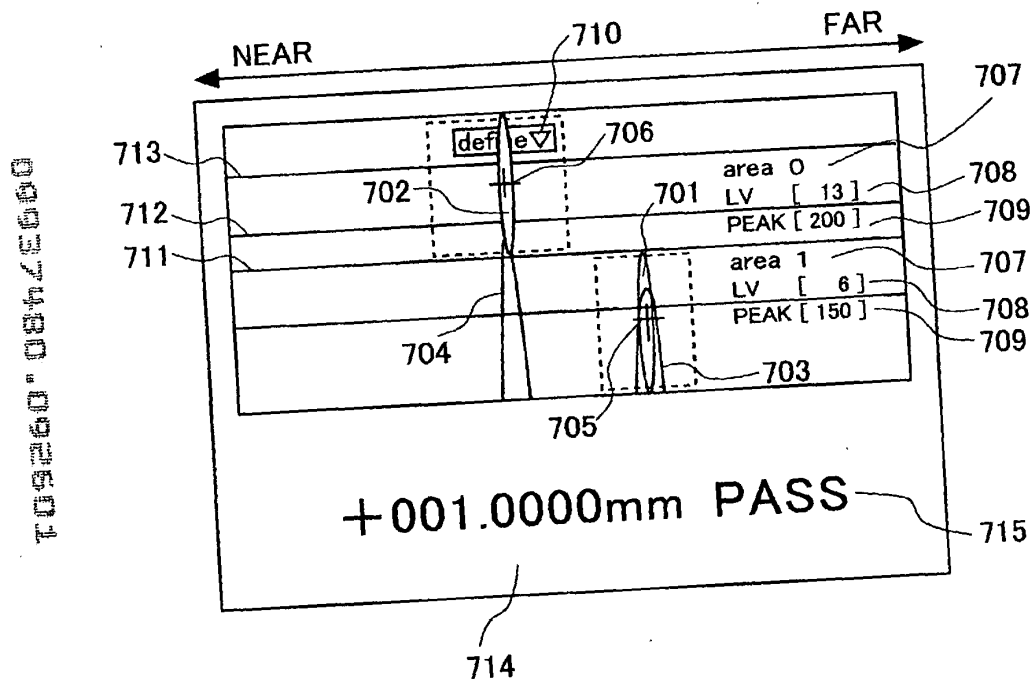
Fig. 19



defining measurement object range 1
→ select only the back surface
for the measurement object range

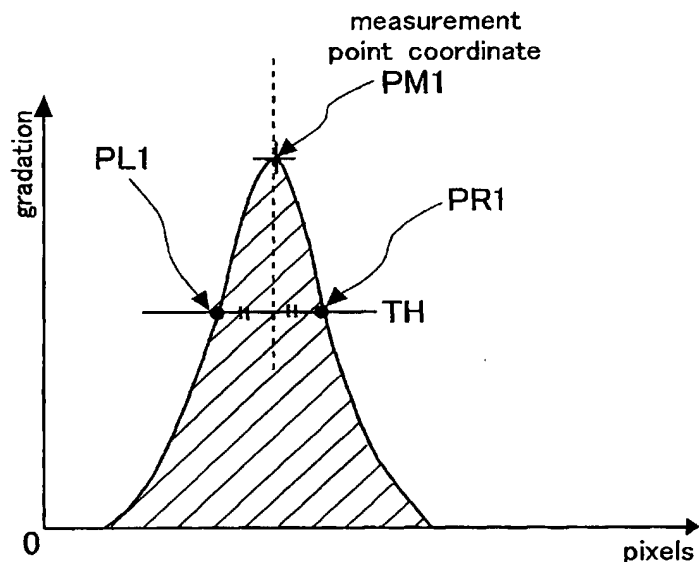
A view illustrating the monitor screen when defining regions (part 3)

Fig.20

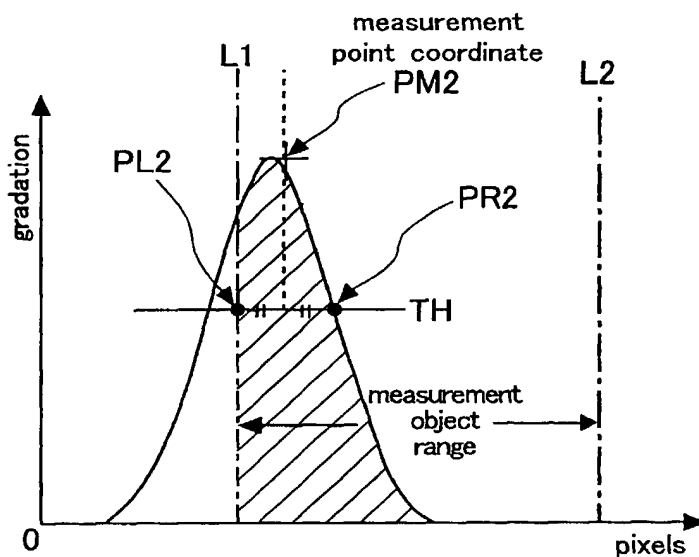


A view illustrating the monitor screen at the time
of measurement after two measurement object ranges are defined

Fig.21



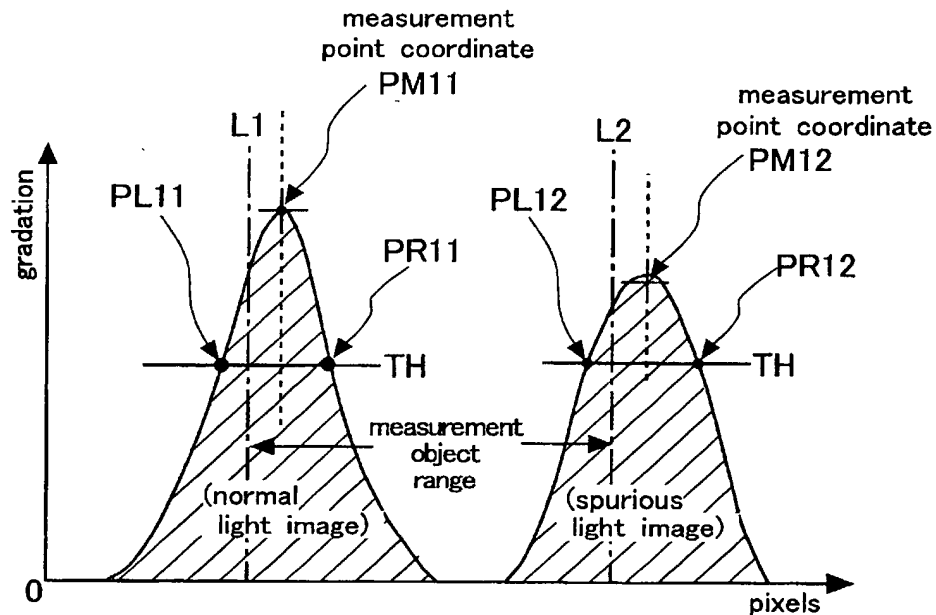
(a) measurement point coordinate extracted from the input image



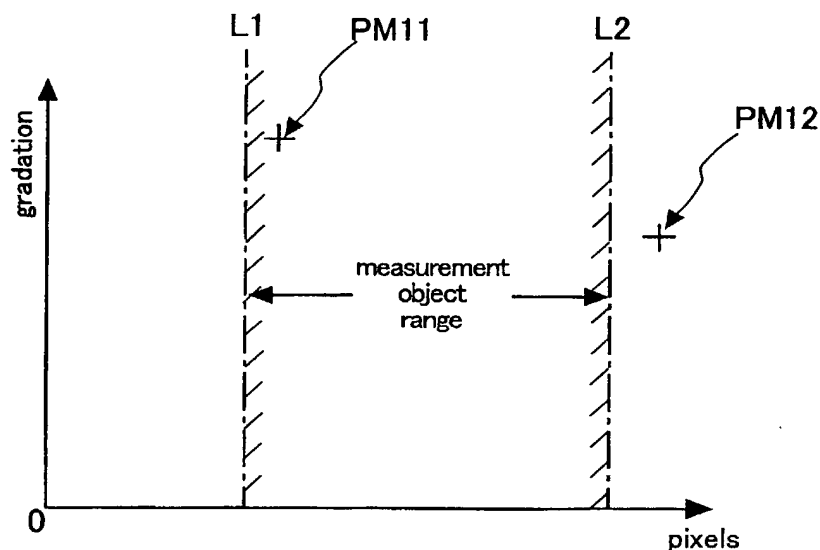
(b) measurement point coordinate extracted from the masked image

A view illustrating the problem with the process
of extracting a measurement point coordinate using a masked image

Fig.22



(a) provisional decision of measurement point coordinates

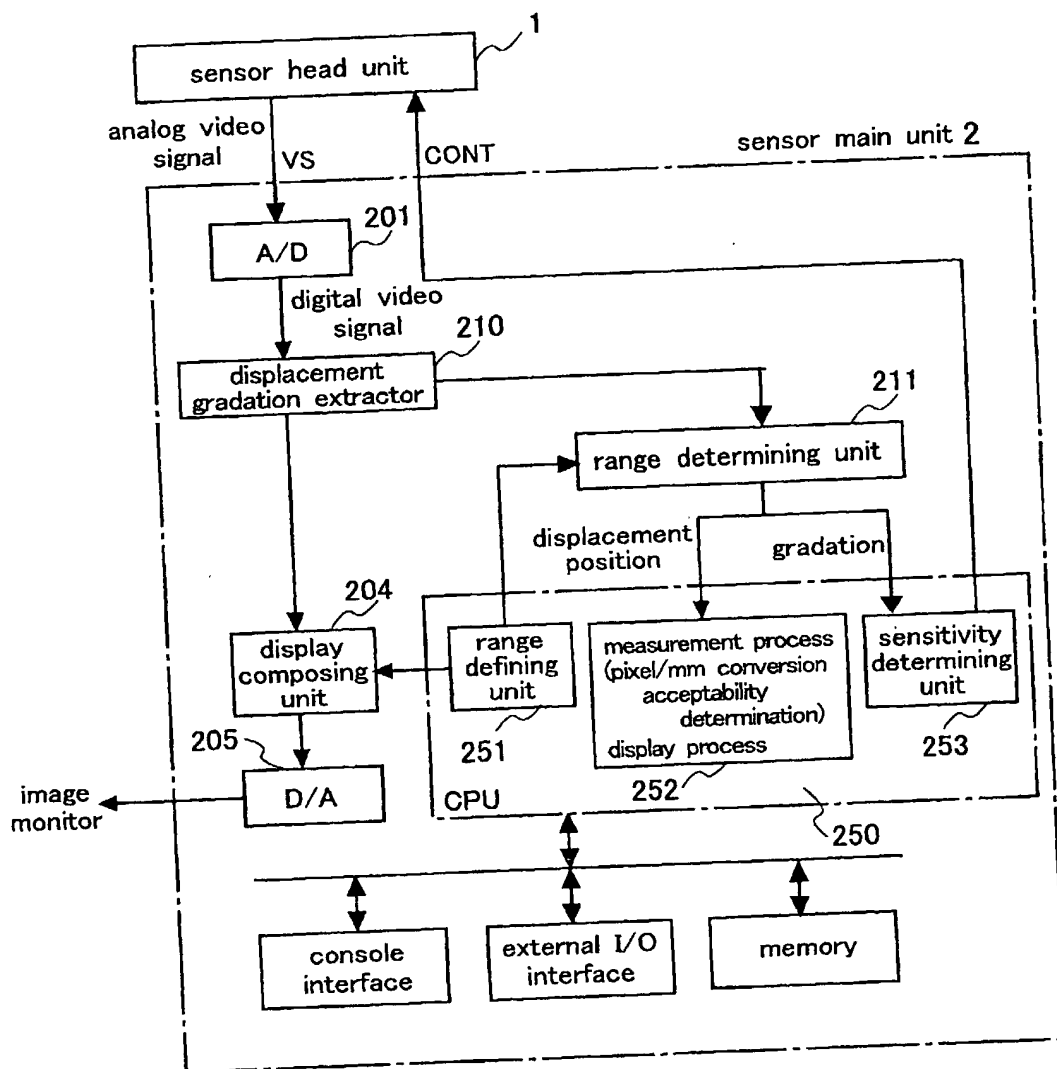


(b) formal decision of measurement point coordinates

A view illustrating the second embodiment of the process
of extracting a measurement point coordinate using a masked image

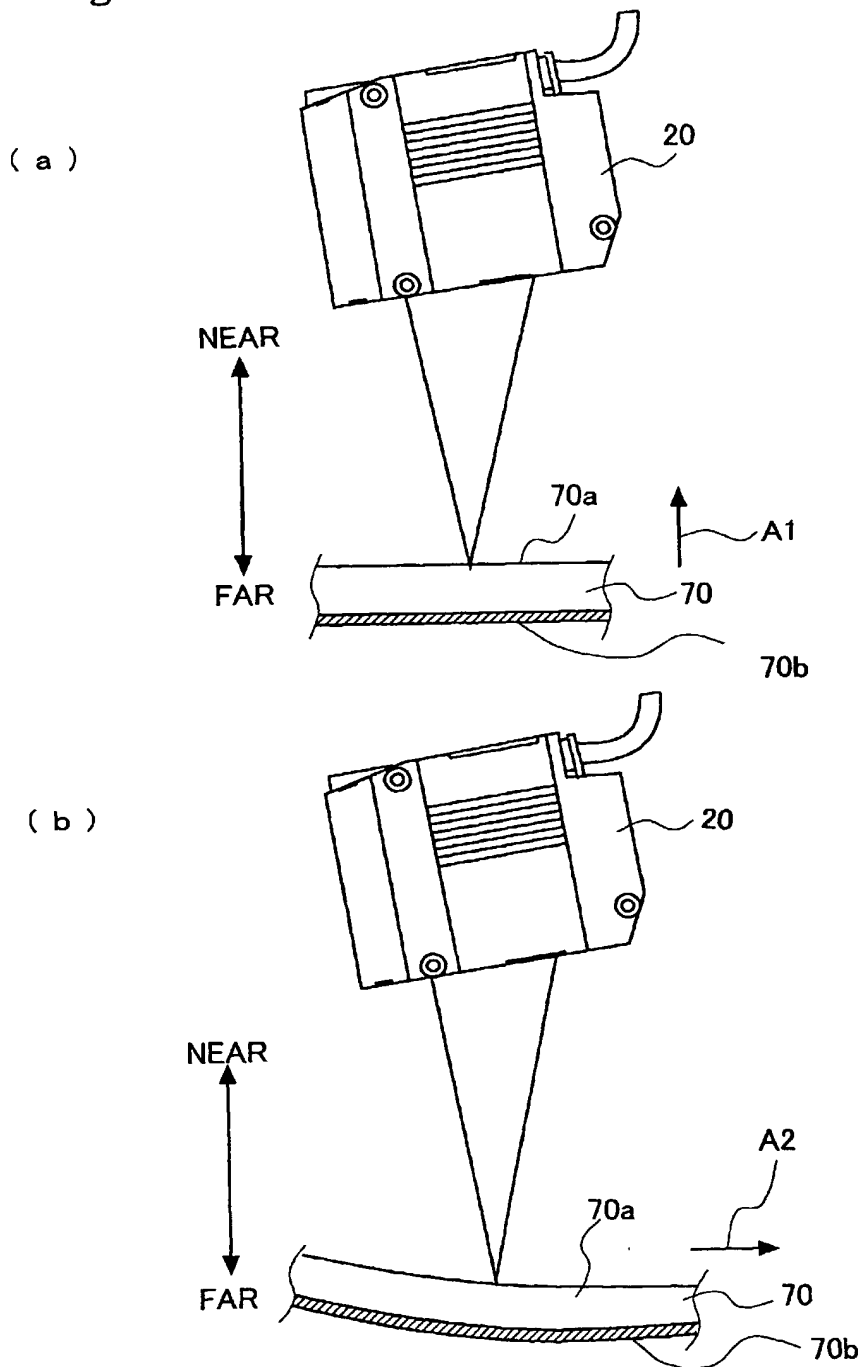
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Fig. 23



A block diagram (part 2)
showing the functional internal structure of the sensor main unit

Fig.24



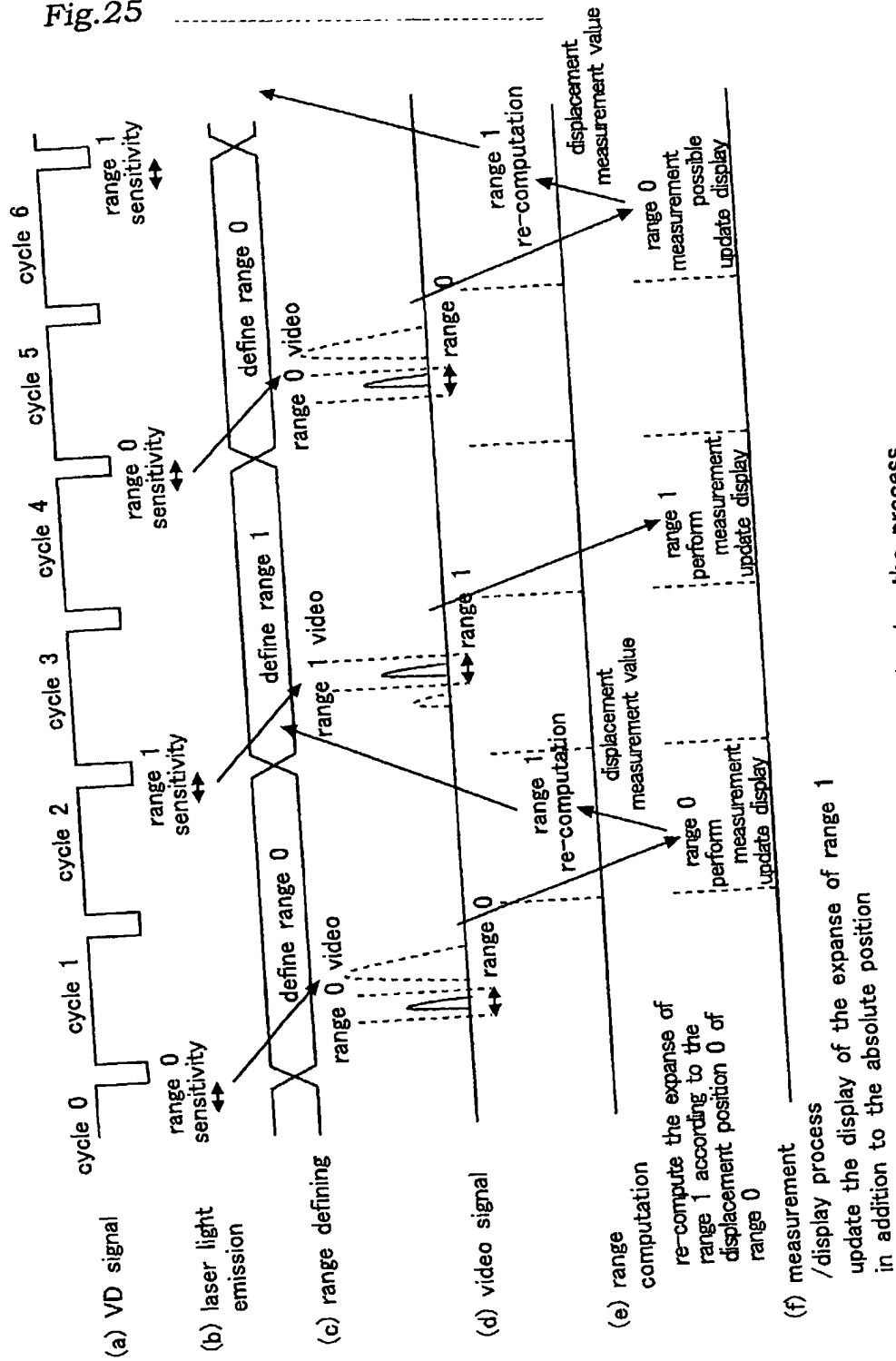
A view showing a mode of vertical changes in a measurement point

109260-0842660

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Inventor(s): Tatsuya Matsunaga, et al.
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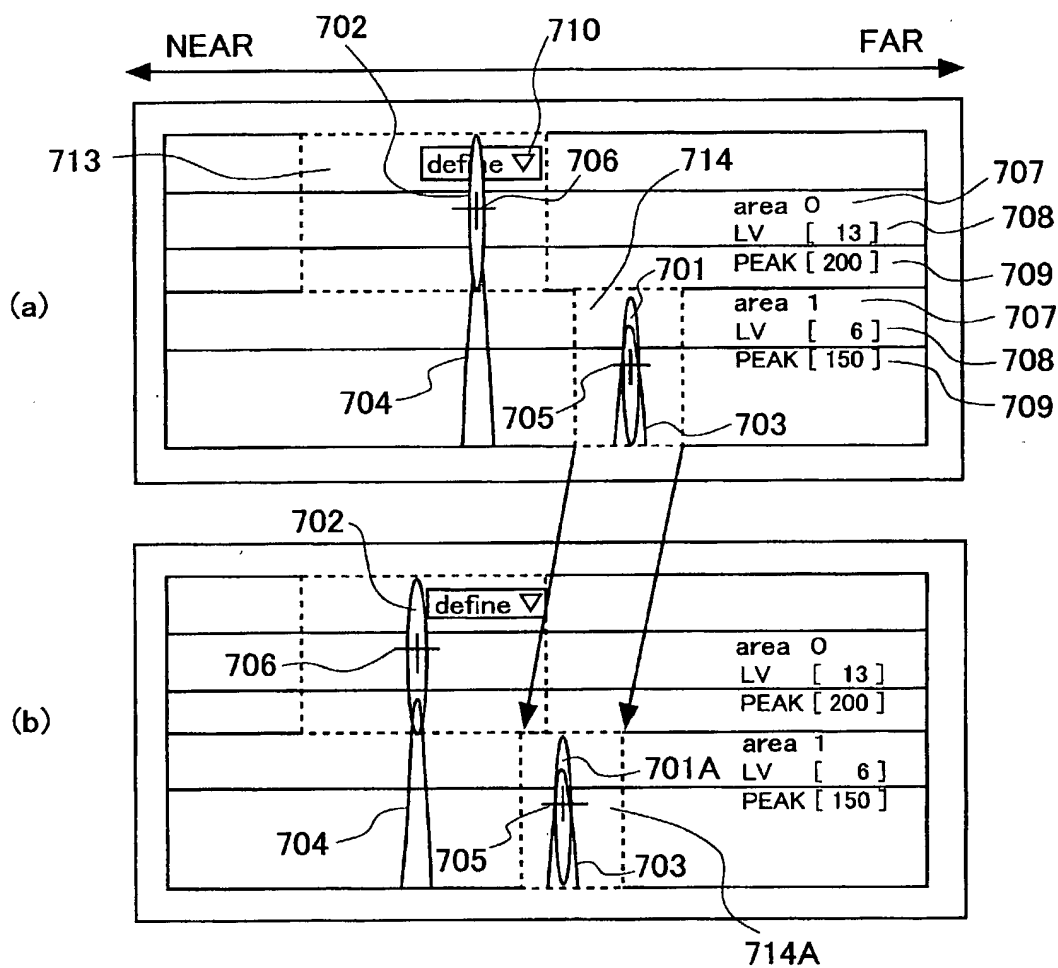
09/937480

Fig.25



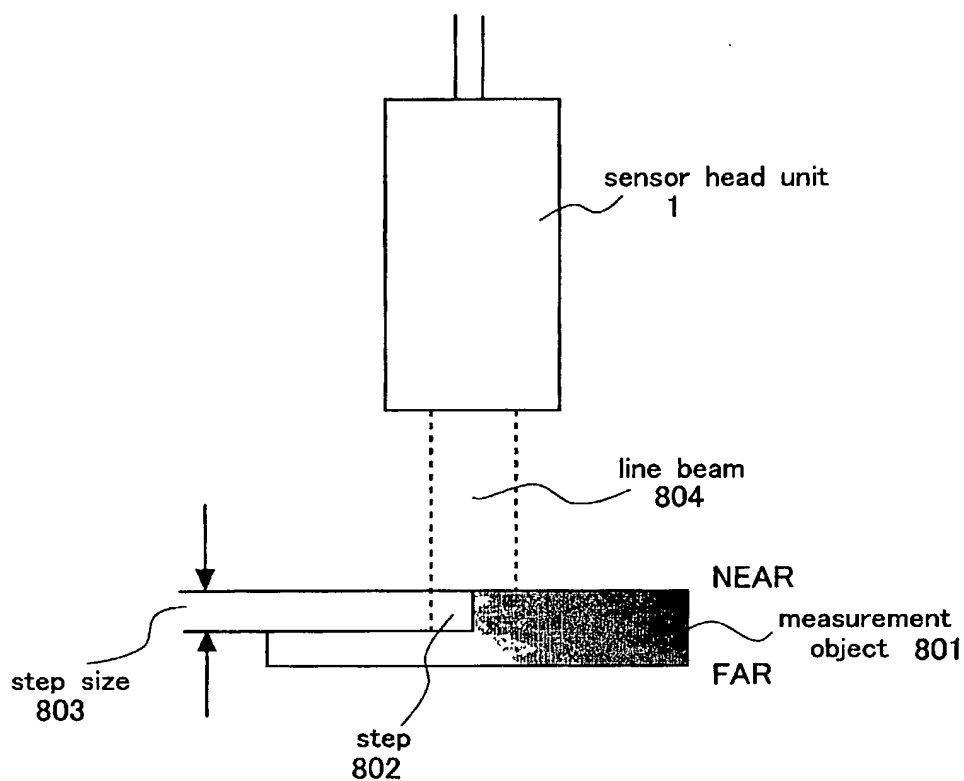
A time chart showing the process
of tracking defined regions to the vertical change in the measurement point

Fig.26



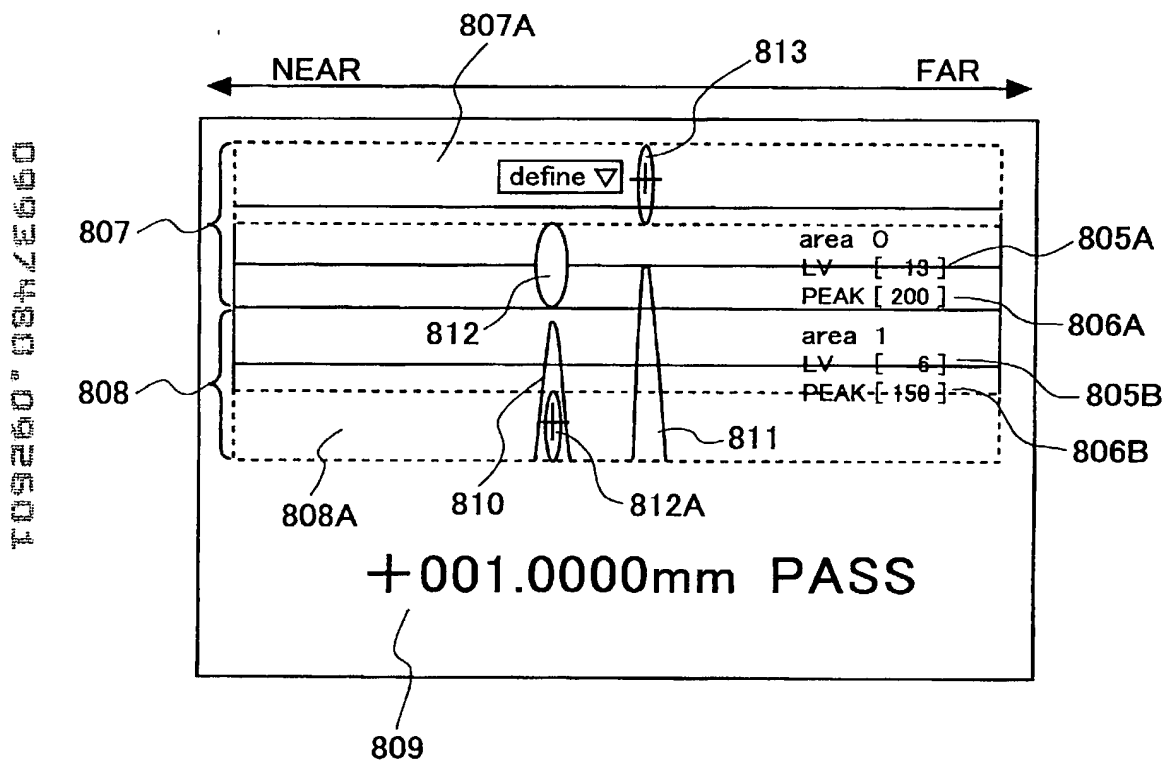
A view showing the monitor screen
before and after the vertical change in the measurement point

Fig.27



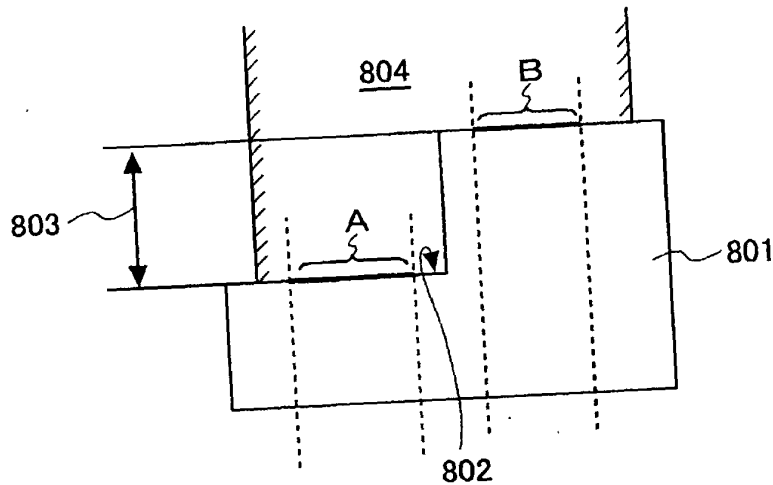
A view illustrating the positional relationship
between the sensor and measurement object when measuring a step

Fig.28

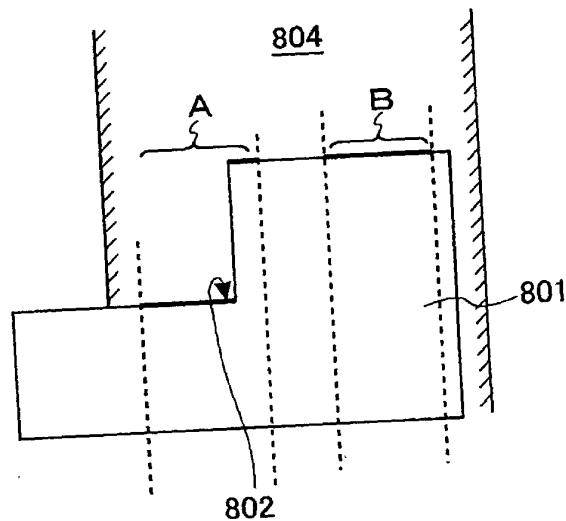


A view showing the monitor screen for the measurement of a step

Fig.29



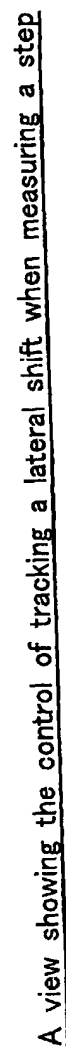
(a) when the measurement object is at the reference position



(b) when the measurement object has shifted laterally

A view illustrating the problem associated with the lateral shifting of the measurement object when measuring a step

0967480-022

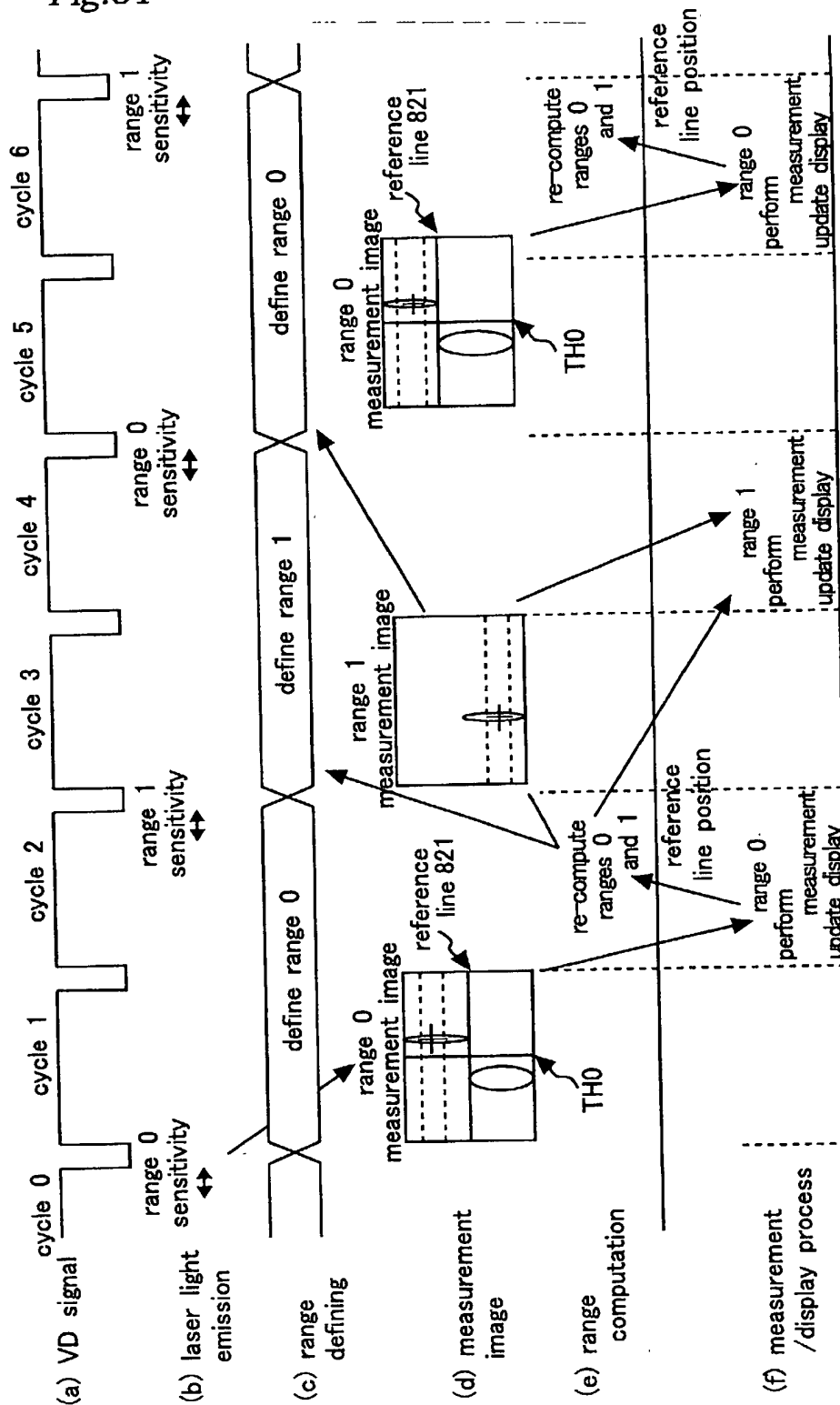


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SENSOR

Inventor(s): Tatsuya Matsunaga, et al.
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Fig.31



A time chart showing the flow of the control process
of tracking a lateral shift when measuring a step

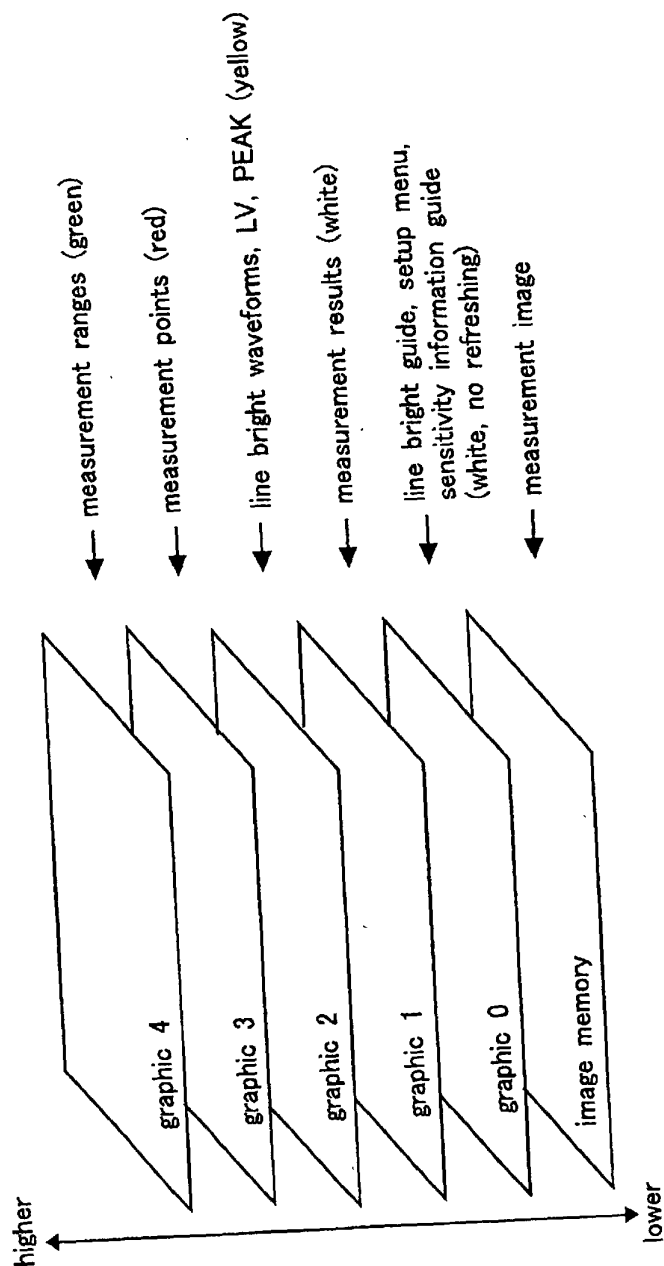
109260*084/E660

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SENSOR

Inventor(s): Tatsuya Matsunaga, et al.
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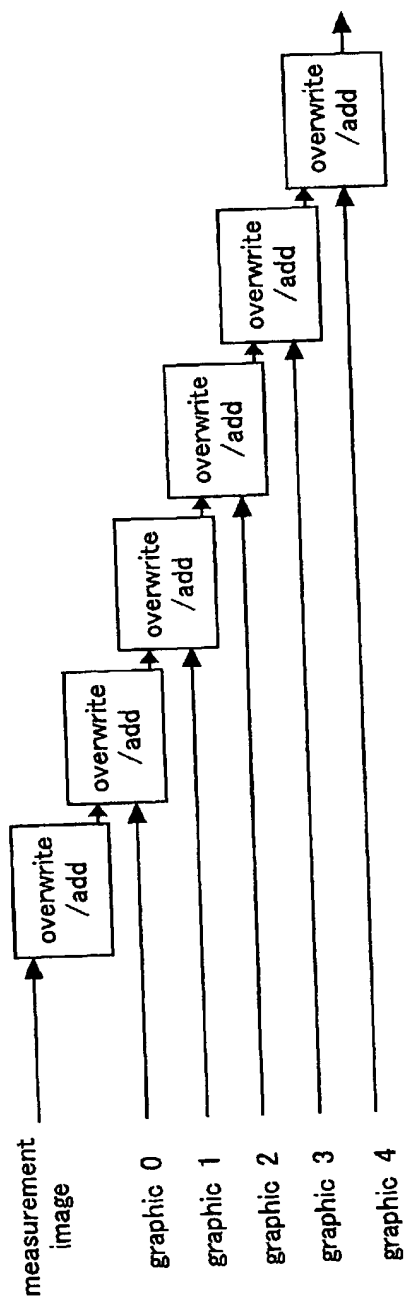
09/937480

Fig.32



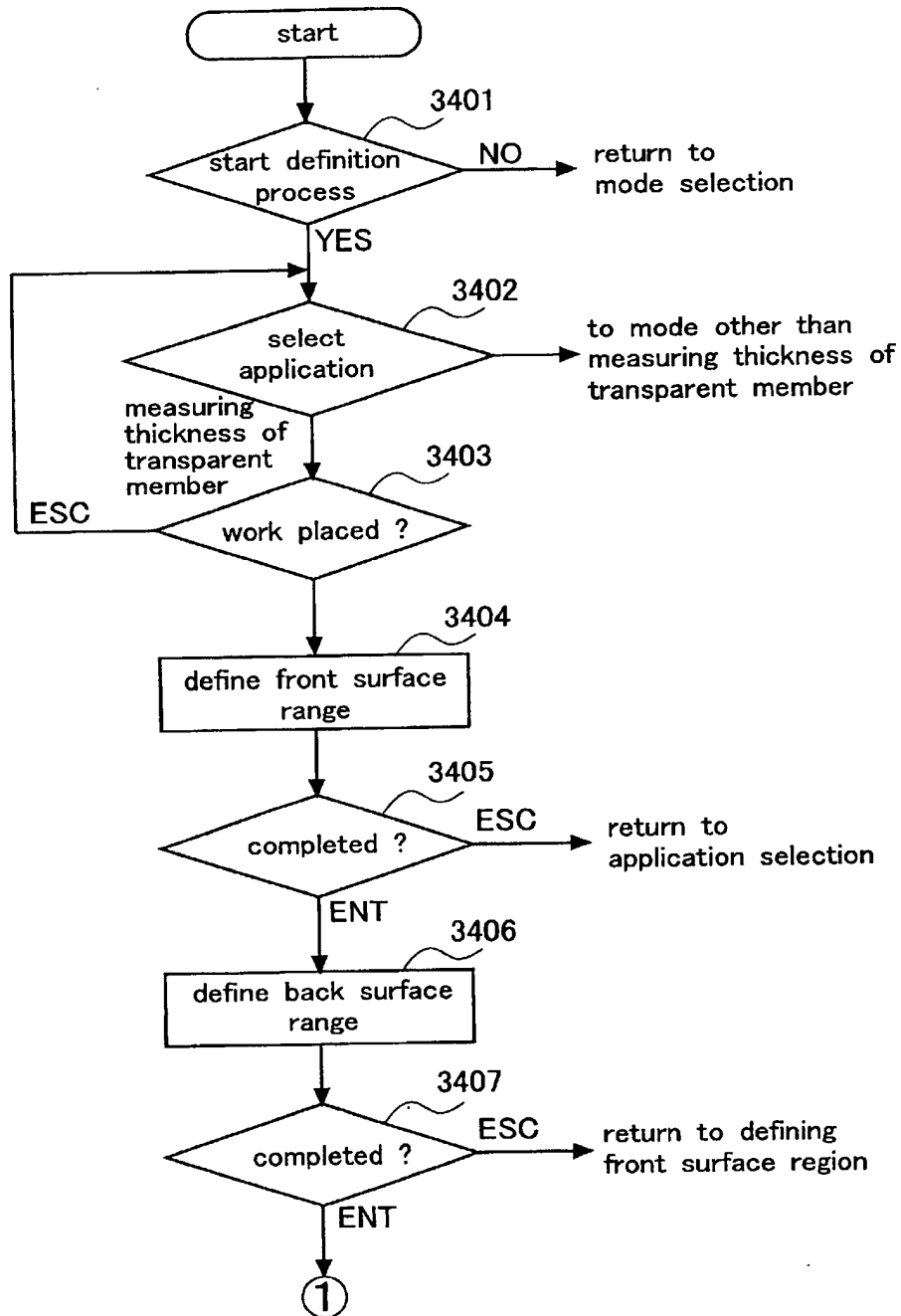
A view illustrating the process of composing a display for the image monitor (part 1)

Fig.33



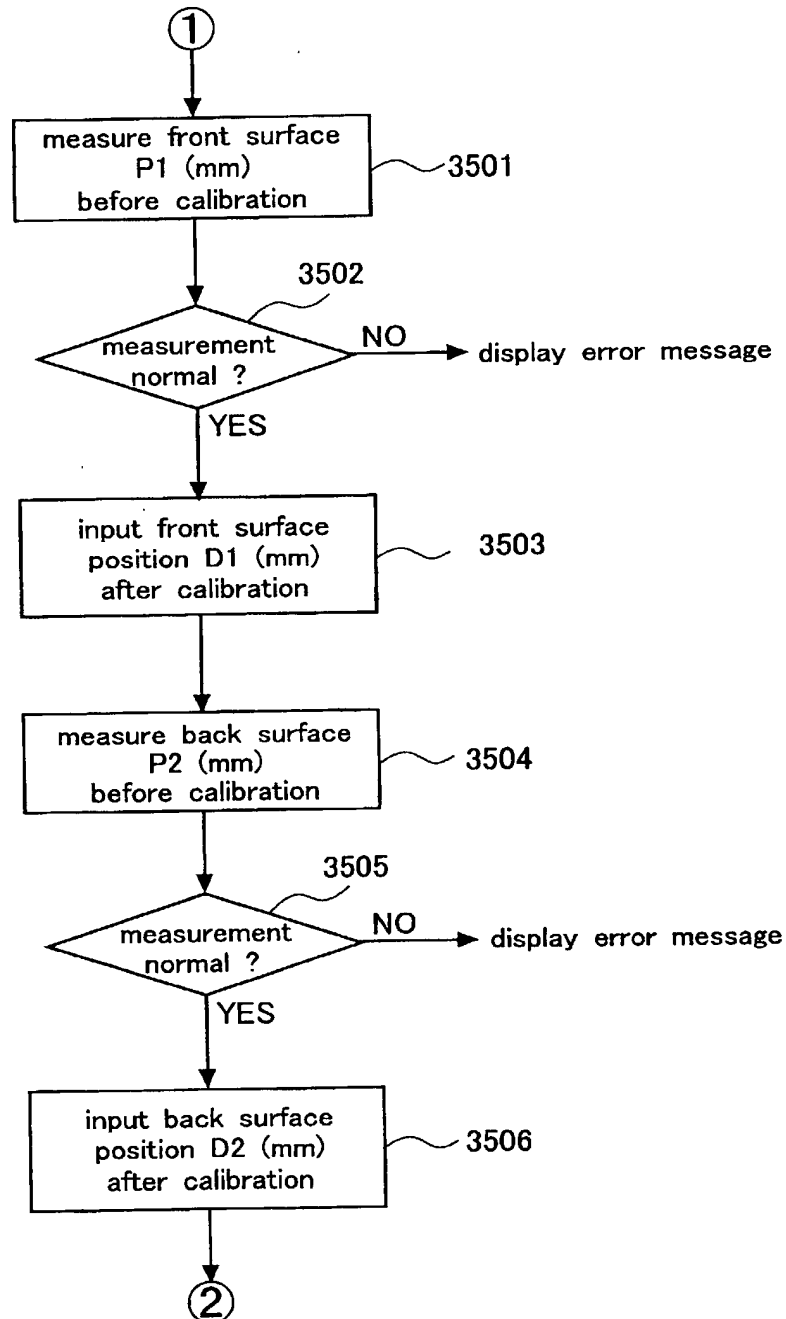
Aviiew illustrating the process of composing a display for the image monitor (part 2)

Fig.34



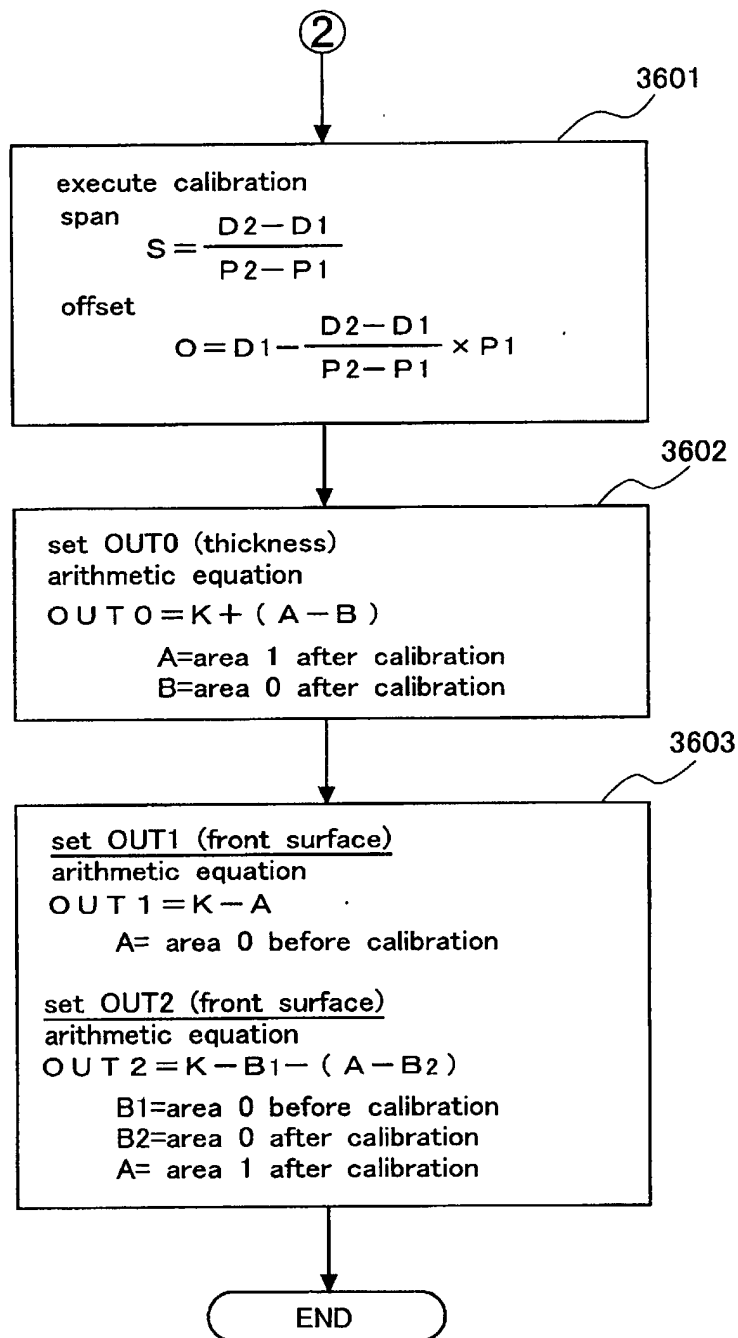
A flow chart showing the calibration process
for the computation of the thickness of a transparent member (part 1)

Fig.35



A flow chart showing the calibration process
for the computation of the thickness of a transparent member (part 2)

Fig.36

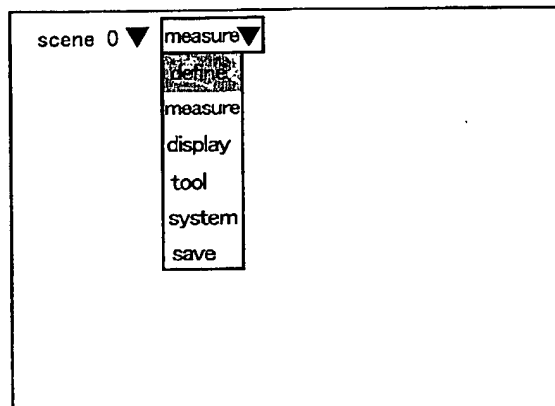


A flow chart showing the calibration process
for the computation of the thickness of a transparent member (part 3)

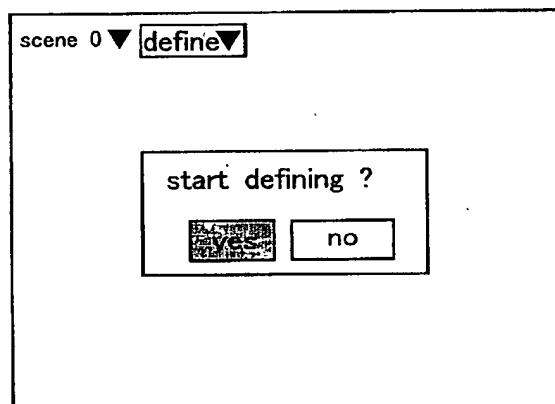
099260-0847E660

Fig.37

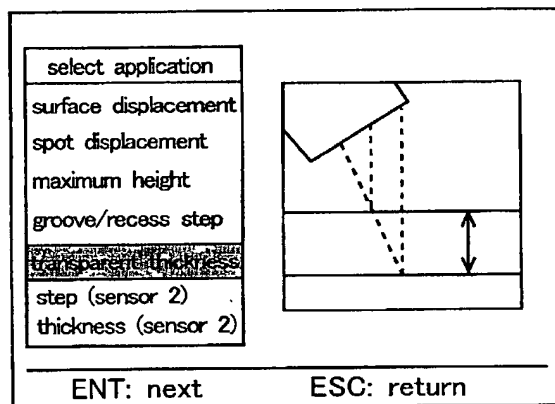
(a)



(b)

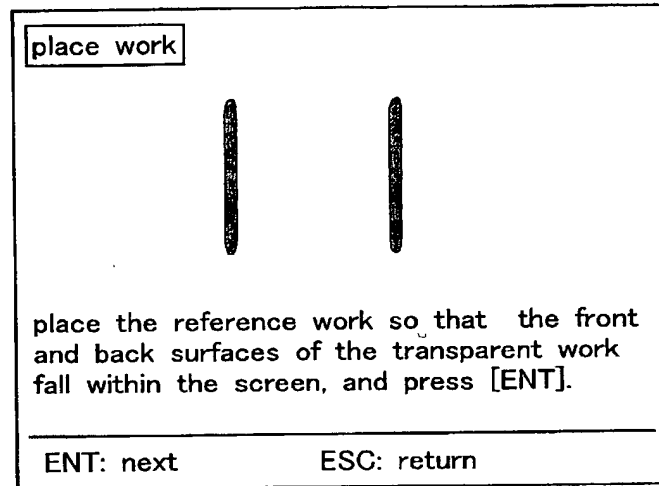


(c)

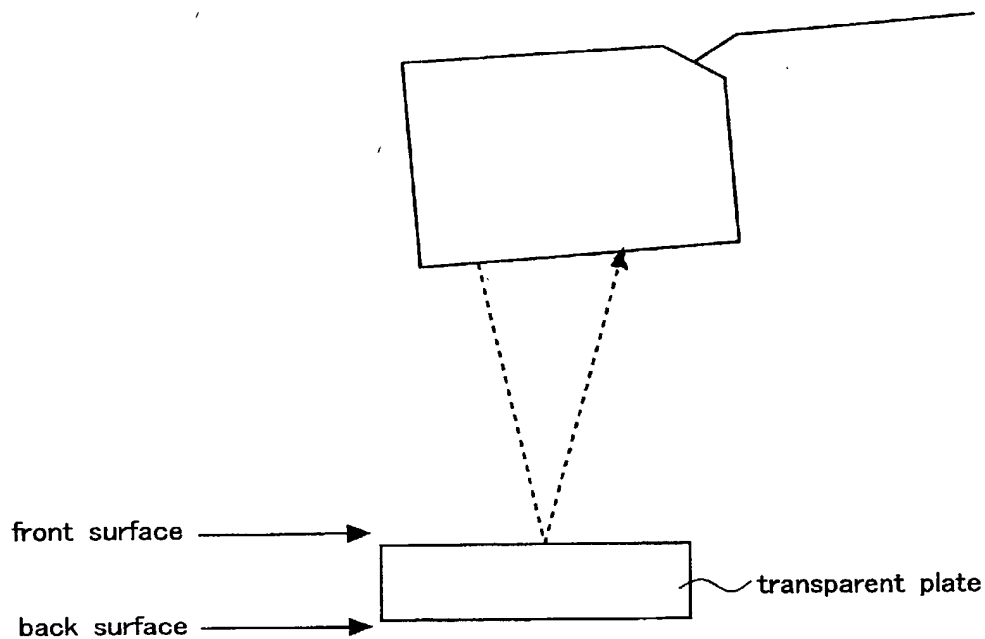


A view showing the monitor screen for the calibration operation
for the computation of the thickness of a transparent member (part 1)

Fig.38



(a)

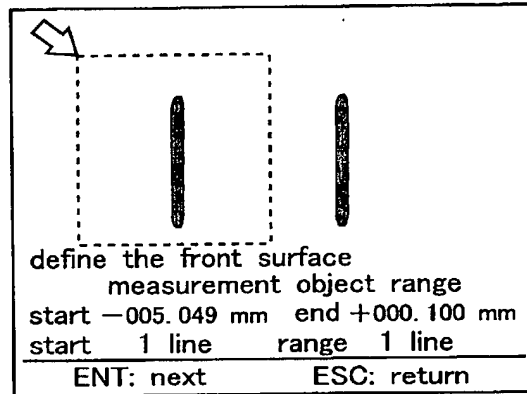


(b)

A view showing the monitor screen for the calibration operation for the computation of the thickness of a transparent member (part 2)

Fig.39

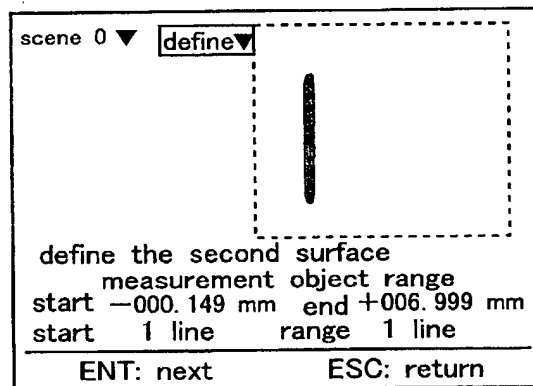
(a)



define the front surface
measurement object range
start -005.049 mm end +000.100 mm
start 1 line range 1 line
ENT: next ESC: return

(b)

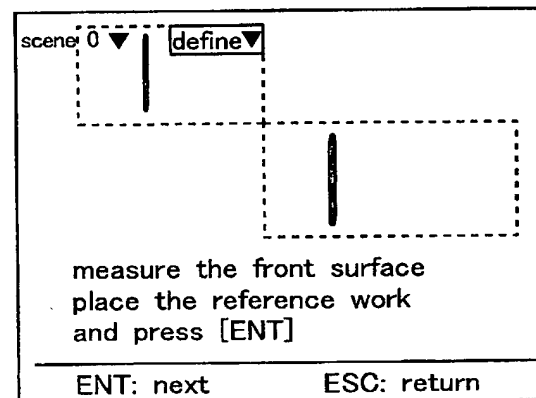
scene 0 ▼ define ▼



define the second surface
measurement object range
start -000.149 mm end +006.999 mm
start 1 line range 1 line
ENT: next ESC: return

(c)

scene 0 ▼ define ▼

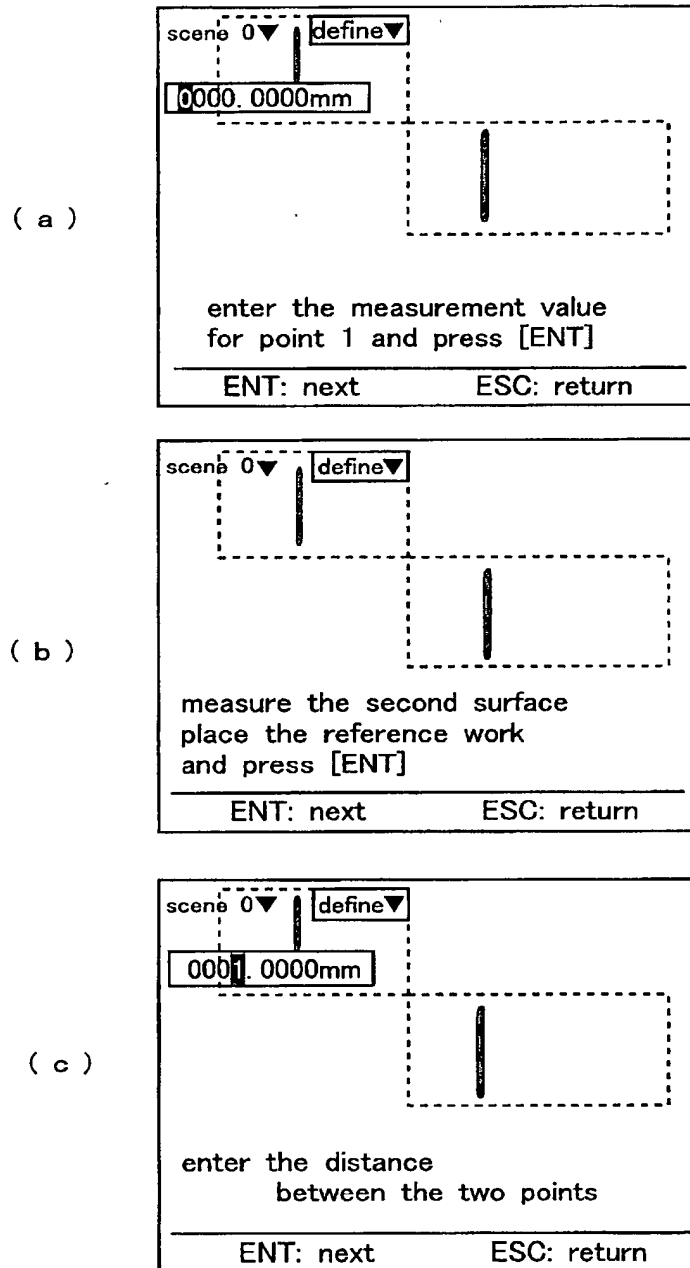


measure the front surface
place the reference work
and press [ENT]
ENT: next ESC: return

A view showing the monitor screen for the calibration operation
for the computation of the thickness of a transparent member (part 3)

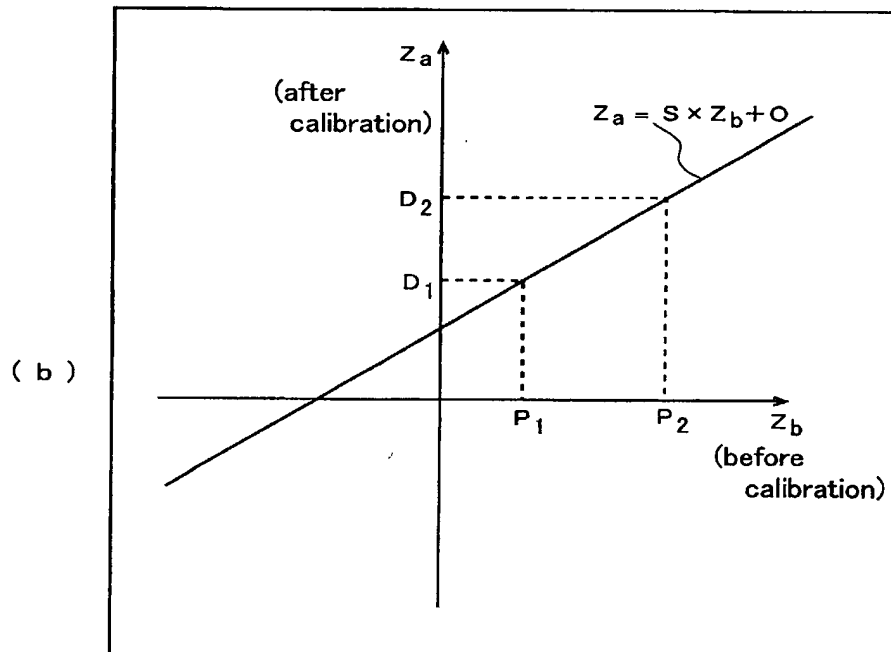
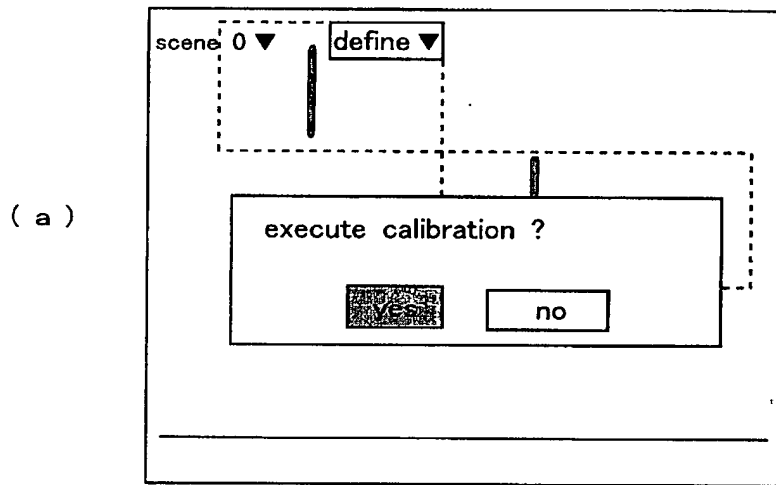
0937480-002601

Fig. 40



A view showing the monitor screen for the calibration operation
for the computation of the thickness of a transparent member (part 4)

Fig.41



A view showing the monitor screen for the calibration operation
for the computation of the thickness of a transparent member (part 5)

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Fig.42

(a)

accept definition / register

application	transparent plate
	thickness
arithmetic equation	$K + (A - B)$
	A = area
	B = area
	register in OUT0

(b)

measurement of each point
can be allocated to the output

front surface → OUT1
back surface → OUT2

(c)

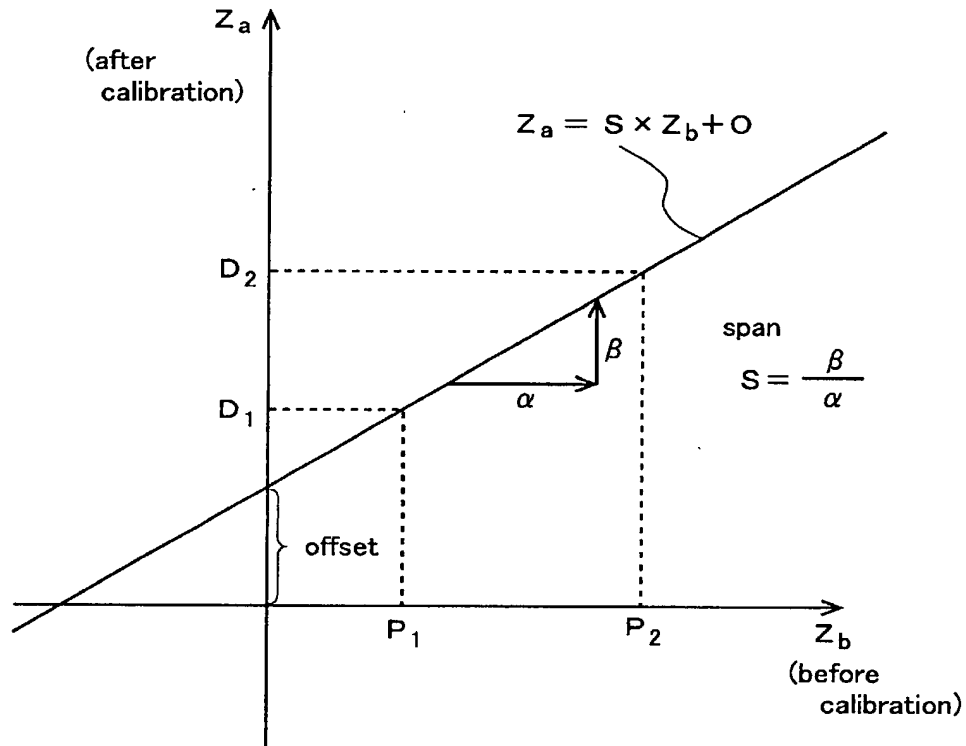
definition complete
proceed to
measurement mode

A view showing the monitor screen for the calibration operation
for the computation of the thickness of a transparent member (part 6)

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SENSOR
Inventor(s): Tatsuya Matsunaga, et al.
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Fig.43



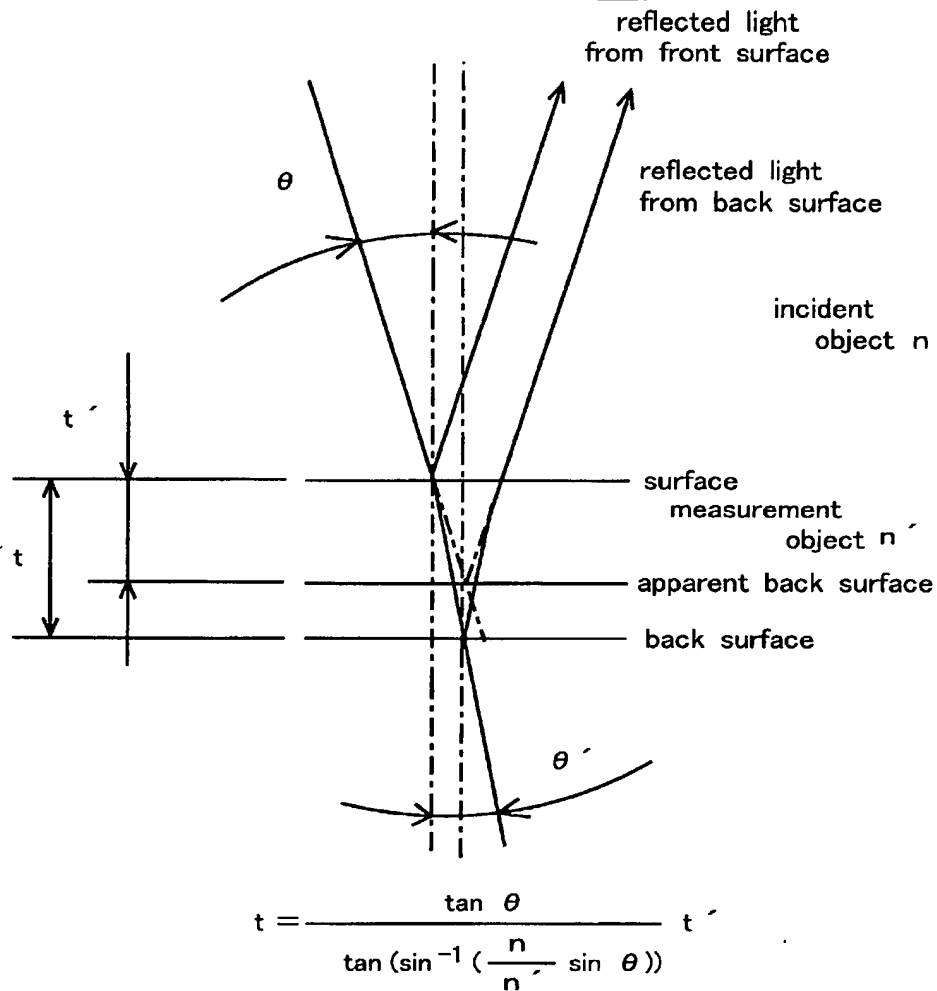
$$S = \frac{D_2 - D_1}{P_2 - P_1}$$

$$O = D_1 - \frac{D_2 - D_1}{P_2 - P_1} \times P_1$$

A view showing the algorithm for the calibration operation
for the computation of the thickness of a transparent member

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Inventor(s): Tatsuya Matsunaga, et al.
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Fig.44



t	: thickness of measurement object
t'	: sensor output value
θ	: sensor light beam incident angle
n	: refractive index of incident object (n=1 normally air)
n'	: refractive index of measurement object

refractive indices of typical transparent materials	
air : 1.002	acrylic : 1.48~1.575
glass : 1.48~1.55	polycarbonate : 1.586
water : 1.333	

A view illustrating the reason for requiring a calibration for the measurement of the thickness of a transparent member by using the visual displacement sensor